Potential Ways to Improve the Supply and Use of Quality-Assured Antibiotics Across Sectors in Developing Countries to Reduce Antimicrobial Resistance

Antimicrobial resistance (AMR) is growing across countries, especially among low- and middle-income countries (LMICs), increasing morbidity, mortality and costs.[1-5] Consequently, a range of measures and initiatives are required to address this urgent public health problem to prevent AMR becoming the next pandemic, especially amongst critical African and Asian countries.[5-9] We have already published Editorials in Advances in Human Biology regarding the potential measures that Governments and Health Authorities could instigate to improve the quality and efficiency of their medicine use, including antibiotics.[10] In addition, potential programmes to reduce the high levels of inappropriate dispensing of antibiotics amongst community pharmacies, especially in LMICs, to reduce AMR.[11] This includes the potential ways to effectively address the challenges with patients in LMICs often requesting antibiotics from prescribers or community pharmacy personnel for typically self-limiting conditions, exacerbated by their limited knowledge of antibiotics and AMR.[12]

Other key areas to address to reduce AMR amongst LMICs include ensuring that key providers, including hospitals, are not faced with the shortages of critical antibiotics.[13] Such a situation can lead to the prescribing of inappropriate or less effective antibiotics, which can result in treatment failures, potentially higher costs with using more expensive antibiotics, over use of broad-spectrum antibiotics, the transfer of patients to other facilities and/or patients being discharged early without full treatment, all potentially adding to AMR.[13-19] The shortages of antibiotics amongst public hospitals in LMICs are exacerbated by concerns with payment, lack of proactivity including a lack of antimicrobial stewardship programmes (ASPs) incorporating therapeutic substitution policies, as well as limited forecasting ability and suboptimal information technology infrastructures.[16,20-22] In addition, sudden changes in prescribing brought about by the changes in pharmaceutical company promotion and against current guidelines including the recent World Health Organization (WHO) AWaRe guidance.[23-28] We are aware that most regional studies assessing the extent of shortages of medicines in hospitals, including antibiotics, as well as potential ways forward, have typically taken place in Europe.[18,29-31]

There is currently a paucity of studies across Africa, as well as amongst Asian countries, assessing the extent of shortages of antibiotics in hospitals, ongoing challenges as well as potential ways forward.[19,32] This needs to be urgently addressed given the additional challenges in LMICs. These include challenges with introducing ASPs as well as available resources and personnel to track and improve antibiotic use in hospitals, in line with the goals in their AMR national action plans.[33-36] In the meantime, there are activities that key hospital personnel can undertake to ensure and improve antibiotic availability and use in their hospitals whilst waiting for the findings from cross-national studies.

Activities include the instigation or updating of hospital antibiotic guidelines. However, any guideline should be based on robust international guidance, including the recent WHO AWaRe book guidance, alongside knowledge of current antibiotic resistance patterns.[5,26,37] Potential guideline targets include initiatives to reduce excessive prescribing of Watch and Reserve antibiotics in hospitals across LMICs to meet the United Nations' goals.[38-43] In addition, reducing current overuse of antibiotics to prevent surgical site infections in hospitals, which is still prevalent across LMICs including African and Asian countries.[40,43] These activities should reduce the need for hospitals to stock and track multiple antibiotics. In addition, focus procurement on a limited number of critical antibiotics to reduce the overall costs. Other activities include improving the monitoring of antibiotic use through improving electronic prescribing systems, instigating therapeutic interchange policies and quickly contacting prescribers to review possible therapeutic interchange and substitution when there are antibiotic shortages.[16,18]

Concerns with antibiotic shortages are principally confined to the hospital sector amongst a number of LMICs.[44] There are shortages of antibiotics in ambulatory care across LMICs; however, this appears mainly amongst primary healthcare centres (PHCs) that may not have sufficient funds to purchase all prescribed antibiotics for their patients; alternatively issues with forecasting leading to shortages.[44]

Concerns with funding the purchasing of antibiotics for PHCs are exacerbated if there are sudden increasing in prices as recently seen in Nigeria.[45,46] As a result, patients typically have to purchase prescribed antibiotics from community pharmacies and other drug sellers. Overall, critical issues generally regarding antibiotics in primary care appear to be more about their overuse and misuse rather than about shortages.[25] The key concerns include current appreciable dispensing of antibiotics without a prescription across LMICs, including those from the WHO Watch list.[44,47-50] The excessive dispensing of antibiotics is exacerbated by their considerable availability, especially where branded generics are available.[44] This is illustrated in Pakistan where there are currently 2186 different brands of cephalosporins available in 6447 presentations and 1333 different brands of quinolones in 2586 presentations, which includes 393 brands of ciprofloxacin with 1158 presentations.[51] The concern is that all these manufacturers are primarily focused on generating a profit, including pushing the government for higher prices.[51,52] Increasing International Nonproprietary Name (INN) prescribing, along with ensuring quality generics, are key steps forward towards to reduce medicine prices and alleviate concerns amongst patients regarding generics.[9,51-53]

Another key area to address to reduce AMR amongst key LMICs is ensuring that patients have access to affordable critical antibiotics in primary care and are not reliant on the informal sector with their worrying levels of cheaper substandard and counterfeit antibiotics.[44-46,54] Increasing INN prescribing, along with enhancing the availability of quality-assured generics, are again crucial steps to reduce the prices of antibiotics, thereby reducing the attractiveness of the market for cheaper substandard antibiotics.[51-54] Possible confusion amongst patients when multiple branded generics of the same molecule are being regularly dispensed will also be reduced by INN prescribing and packaging.[51-53] Making antibiotics affordable will also reduce current practices among LMICs whereby antibiotics are stopped when patients feel better and are subsequently shared amongst families and friends, which should reduce AMR.[44,45] These critical issues all need to be addressed moving forward among LMICs to reduce AMR, with primary care accounting for up to 95% of total antibiotic consumption amongst humans in developing countries.[55]

The high reliance on the informal sector across LMICs is the result of several factors. These include readily available antibiotics in this sector as well as their affordability when the costs of visiting prescribers in healthcare clinics, alongside any dispensing costs, are factored in.[56,57] This is a concern with, as mentioned, the greater dispensing of substandard and counterfeit medicines in informal versus formal sectors, contributing to AMR, with antibiotics accounting for the majority of counterfeit medicines currently seen.[44,54,58-63] The informal sector is typically defined as containing unlicensed outlets, which may exist in shops, charge fees for their services typically in cash and staffed by people with minimal training.[64-67] The lack of training of staff in the informal sector, coupled with a higher prevalence of substandard and counterfeit antibiotics, adds to the growth of AMR in LMICs.[59,61]

The first steps with reducing reliance on the informal sector for antibiotics across LMICs includes assessing the extent of the problem and the rationale behind the use of antibiotics. These are planned activities for the future, building on previous studies and reviews.[44,64,66-68] In the meantime, we are seeing multiple activities across countries and continents to improve the quality of antibiotics being dispensed as well as to reduce the extent of counterfeit antibiotics being sold.[44] Activities to improve the quality of antibiotics being dispensed include the WHO's 'Lomé Initiative' combined with for instance the establishment of the African Medicines Agency to help upgrade and harmonise regulatory activities across the continent as well as reduce duplication of effort.[69-72] Reducing duplication will release more officers to track the presence of substandard and counterfeit antibiotics in the country.[73] Alongside this, improved co-ordination with Interpol across Africa and Asia to track down suppliers of counterfeit antibiotics, which is already happening.[74-77]

Other potential activities to improve the quality of available antibiotics in LMICs include compulsory re-registration and/or the removal of licenses where substandard antibiotics are detected.[60,78] Combined with this, aggressive sanctions for manufacturers and suppliers, including informal suppliers, when counterfeit medicines are found. Activities could include removal of licences to operate/import antibiotics, extensive fines, disruption of informal sites and prison sentences.[54,75,79] Other activities include improved packaging and the traceability of available antibiotics.[54,62,80] We have already seen the Indian government forming a task force to tackle issues with falsified medicines through a number of activities including placing unique identification numbers and a bar code on medicine packs-containing antibiotics,[77,81,82] with similar activities in other LMICs.[62,83] Additional measures include streamlining the supply chains to improve traceability and reduce costs, especially since these are currently complex.[84] Furthermore, focusing prescribing and dispensing of antibiotics for infectious diseases on the small number recommended in the WHO AWaRe guidance.[26,27] Limiting the number of antibiotics used and their dosage should also help streamline production, including local production of antibiotics, thereby reducing costs and the attractiveness of this market for the informal sector.[44]

In conclusion, there are multiple activities that key stakeholders can undertake across LMICs to improve future antibiotic use and reduce rising AMR rates. This includes proactively tackling antibiotic shortages in hospitals as well as implementing multiple inter-related measures to reduce the availability of counterfeit antibiotics in ambulatory care alongside the attractiveness of the informal sector. By doing so, help reduce affordability as a barrier to accessing and completing full

courses of antibiotics in ambulatory care. We will continue to explore these issues in upcoming planned research projects to provide future targeted direction.

Mukhethwa Munzhedzi[1,2], Santosh Kumar[3], Brian Godman[1,4,5], Johanna C Meyer[1,2]

[1]Department of Public Health Pharmacy and Management, School of Pharmacy, Sefako Makgatho Health Sciences University, [2]South African Vaccination and Immunisation Centre, Sefako Makgatho Health Sciences University, Ga-Rankuwa, Pretoria, South Africa, [3]Department of Periodontology and Implantology, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India, [4]Department of Pharmacoepidemiology, Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow, [5]Antibiotic Policy Group, Institute for Infection and Immunity, City St. George's, University of London, London, UK

Address for correspondence: Prof. Brian Godman, Strathclyde Institute of Pharmacy and Biomedical Sciences, University of Strathclyde, Glasgow G4 0RE, UK.
E-mail: brian.godman@strath.ac.uk

Submitted: 10-Jun-2025 **Revised:** 17-Jun-2025
Accepted: 23-Jun-2025 **Published:** 21-Aug-2025

References

1. Cassini A, Högberg LD, Plachouras D, Quattrocchi A, Hoxha A, Simonsen GS, *et al*. Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: A population-level modelling analysis. Lancet Infect Dis 2019;19:56-66.
2. Antimicrobial Resistance Collaborators. The burden of bacterial antimicrobial resistance in the WHO African region in 2019: A cross-country systematic analysis. Lancet Glob Health 2024;12:e201-16.
3. Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. Lancet 2022;399:629-55.
4. Hofer U. The cost of antimicrobial resistance. Nat Rev Microbiol 2019;17:3.
5. Ho CS, Wong CT, Aung TT, Lakshminarayanan R, Mehta JS, Rauz S, *et al*. Antimicrobial resistance: A concise update. Lancet Microbe 2025;6:100947.
6. Gautam A. Antimicrobial resistance: The next probable pandemic. J Nepal Med Assoc 2022;60:225-8.
7. Sulis G, Sayood S, Gandra S. Antimicrobial resistance in low- and middle-income countries: Current status and future directions. Expert Rev Anti Infect Ther 2022;20:147-60.
8. Kariuki S, Kering K, Wairimu C, Onsare R, Mbae C. Antimicrobial resistance rates and surveillance in Sub-Saharan Africa: Where are we now? Infect Drug Resist 2022;15:3589-609.
9. Lubanga AF, Bwanali AN, Kambiri F, Harawa G, Mudenda S, Mpinganjira SL, *et al*. Tackling antimicrobial resistance in Sub-Saharan Africa: Challenges and opportunities for implementing the new people-centered WHO guidelines. Expert Rev Anti Infect Ther 2024;22:379-86.
10. Godman B. Health authority activities to enhance the quality and efficiency of medicine use and their impact. Adv Hum Biol 2021;11:11-6.
11. Sono TM, Markovic-Pekovic V, Godman B. Effective programmes to reduce inappropriate dispensing of antibiotics in community pharmacies especially in developing countries. Adv Hum Biol 2024;14:1-4.
12. Sono TM, Schellack N, Godman B. The role of patients with addressing inappropriate dispensing of antibiotics without a prescription especially in developing countries. Adv Hum Biol 2025;15:1-4.
13. Allaw F, Vu Thi Lan H, Nagao M, Ndegwa L, Levy Hara G, Kanj SS, *et al*. Antibiotic shortages: An overview by the alliance for the prudent use of antibiotics (APUA). Int J Antimicrob Agents 2025;65:107456.
14. Pandey AK, Cohn J, Nampoothiri V, Gadde U, Ghataure A, Kakkar AK, *et al*. A systematic review of antibiotic drug shortages and the strategies employed for managing these shortages. Clin Microbiol Infect 2025;31:345-53.
15. Shafiq N, Pandey AK, Malhotra S, Holmes A, Mendelson M, Malpani R, *et al*. Shortage of essential antimicrobials: A major challenge to global health security. BMJ Glob Health 2021;6:e006961.
16. Chigome AK, Matlala M, Godman B, Meyer JC. Availability and use of therapeutic interchange policies in managing antimicrobial shortages among South African public sector hospitals; findings and implications. Antibiotics (Basel) 2019;9:4.
17. Uda A, Onuma K, Shigemura K, Kitagawa K, Yan Y, Osawa K, *et al*. Impact of cefazolin shortage on clinical outcomes of adult patients with bacteremia caused by methicillin-susceptible *Staphylococcus aureus* in a tertiary care university hospital. Antibiotics 2021;10:1247.
18. Miljković N, Godman B, van Overbeeke E, Kovačević M, Tsiakitzis K, Apatsidou A, *et al*. Risks in antibiotic substitution following medicine shortage: A health-care failure mode and effect analysis of six European hospitals. Front Med 2020;7:157.
19. Basu S, Copana R, Morales R Jr., Anugulruengkitt S, Puthanakit T, Maramba-Lazarte C, *et al.* Keeping it real: Antibiotic use problems and stewardship solutions in low- and middle-income countries. Pediatr Infect Dis J 2022;41:S18-25.
20. Modisakeng C, Matlala M, Godman B, Meyer JC. Medicine shortages and challenges with the procurement process among public sector hospitals in South Africa; findings and implications. BMC Health Serv Res 2020;20:234.
21. Falco MF, Meyer JC, Putter SJ, Underwood RS, Nabayiga H, Opanga S, *et al*. Perceptions of and practical experience with the national surveillance centre in managing medicines availability amongst users within public healthcare facilities in South Africa: Findings and implications. Healthcare 2023;11:1838.
22. Kuruc Poje D, Miljković N, Polidori P, Kohl S. Infectious diseases and antimicrobial resistance. Eur J Hosp Pharm 2025;32:186-9.
23. Fadare JO, Oshikoya KA, Ogunleye OO, Desalu OO, Ferrario A, Enwere OO, *et al.* Drug promotional activities in Nigeria: Impact on the prescribing patterns and practices of medical practitioners and the implications. Hosp Pract 2018;46:77-87.
24. Fadare JO, Bankole I, Babatola A, Simeon Olatunya O, Aina F, Godman B. Adherence to WHO criteria on drug promotion literature: An exploratory study from a tertiary healthcare facility in South-West Nigeria. Hosp Pharm 2023;58:62-9.
25. Saleem Z, Moore CE, Kalungia AC, Schellack N, Ogunleye O, Chigome A, *et al*. Status and implications of the knowledge, attitudes and practices towards AWaRe antibiotic use, resistance and stewardship among low- and middle-income countries. JAC Antimicrob Resist 2025;7:dlaf033.
26. Zanichelli V, Sharland M, Cappello B, Moja L, Getahun H, Pessoa-Silva C, *et al*. The WHO AWaRe (Access, Watch, Reserve) antibiotic book and prevention of antimicrobial resistance. Bull World Health Organ 2023;101:290-6.
27. Sharland M, Zanichelli V, Ombajo LA, Bazira J, Cappello B, Chitatanga R, *et al*. The WHO essential medicines list AWaRe book: From a list to a quality improvement system. Clin Microbiol Infect 2022;28:1533-5.
28. Riaz H, Godman BB, Hussain S, Malik F, Mahmood S, Shami AM, *et al*. Prescribing of bisphosphonates and antibiotics in Pakistan: Challenges and opportunities for the future. J Pharm Health Serv Res 2015;6:111-21.
29. Miljković N, Polidori P, Kohl S. Managing antibiotic shortages: Lessons from EAHP and ECDC surveys. Eur J Hosp Pharm 2022;29:90-4.
30. Miljković N, van Overbeeke E, Godman B, Kovačević M, Anastasi A, Bochenek T, *et al*. Practical implications from European hospital pharmacists on prospective risk assessment for medicine shortages. Front Med 2020;7:407.
31. Miljković N, Polidori P, Leonardi Vinci D, Kuruc Poje D, Makridaki D, Kohl S, *et al*. Results of EAHP's 2023 shortages survey. Eur J Hosp Pharm 2025;32:307-15.
32. Alemkere G, Teshome A, Temesgen G, Abebe G, Degefaw Y, Tilahun H, *et al*. Cefazolin access and use in Ethiopia: A policy implication. PLOS Glob Public Health 2023;3:e0001421.
33. Cox JA, Vlieghe E, Mendelson M, Wertheim H, Ndegwa L, Villegas MV, *et al.* Antibiotic stewardship in low- and middle-income countries: The same but different? Clin Microbiol Infect 2017;23:812-8.8.
34. Charani E, Mendelson M, Pallett SJ, Ahmad R, Mpundu M, Mbamalu O,

et al. An analysis of existing national action plans for antimicrobial resistance-gaps and opportunities in strategies optimising antibiotic use in human populations. Lancet Glob Health 2023;11:e466-74.
35. Ohemu GP. Starved of ACTION: A critical look at the antimicrobial resistance action plans of African countries. ACS Infect Dis 2022;8:1377-80.
36. Godman B, Egwuenu A, Wesangula E, Schellack N, Kalungia AC, Tiroyakgosi C, *et al*. Tackling antimicrobial resistance across Sub-Saharan Africa: Current challenges and implications for the future. Expert Opin Drug Saf 2022;21:1089-111.
37. Moja L, Zanichelli V, Mertz D, Gandra S, Cappello B, Cooke GS, *et al*. WHO's essential medicines and AWaRe: Recommendations on first- and second-choice antibiotics for empiric treatment of clinical infections. Clin Microbiol Infect 2024;30 Suppl 2:S1-51.
38. United Nations. Political Declaration of the High-Level Meeting on Antimicrobial Resistance; 2024. Available from: https://www.un.org/pga/wp-content/uploads/sites/108/2024/09/FINAL-Text-AMR-to-PGA.pdf. [Last accessed on 2025 May 10].
39. Sulis G, Sayood S, Katukoori S, Bollam N, George I, Yaeger LH, *et al*. Exposure to World Health Organization's AWaRe antibiotics and isolation of multidrug resistant bacteria: A systematic review and meta-analysis. Clin Microbiol Infect 2022;28:1193-202.
40. Saleem Z, Godman B, Cook A, Khan MA, Campbell SM, Seaton RA, *et al*. Ongoing efforts to improve antimicrobial utilization in hospitals among African countries and implications for the future. Antibiotics 2022;11:1824.
41. Haseeb A, Saleem Z, Maqadmi AF, Allehyani RA, Mahrous AJ, Elrggal ME, *et al*. Ongoing strategies to improve antimicrobial utilization in hospitals across the Middle East and North Africa (MENA): Findings and implications. Antibiotics 2023;12:827.
42. Mustafa ZU, Salman M, Khan AH, Harun SN, Meyer JC, Godman B. Antimicrobial use among hospitalized neonates and children; findings and implications from a comprehensive point prevalence survey among general tertiary hospitals in Pakistan. Infect Drug Resist 2024;17:5411-28.
43. Mwita JC, Ogunleye OO, Olalekan A, Kalungia AC, Kurdi A, Saleem Z, *et al*. Key issues surrounding appropriate antibiotic use for prevention of surgical site infections in low- and middle-income countries: A narrative review and the implications. Int J Gen Med 2021;14:515-30.
44. Saleem Z, Mekonnen BA, Orubu ES, Islam MA, Nguyen TT, Ubaka CM, *et al*. Current access, availability and use of antibiotics in primary care among key low- and middle-income countries and the policy implications. Expert Rev Anti Infect Ther 2025:1-42.
45. Gulumbe BH, Abdulrahim A, Ibrahim MN. Rising antibiotic costs as a potential driver of antimicrobial resistance in Nigeria. Discov Public Health 2025;22:8.
46. Ifeanyichukwu A, Chimezie E, Danjuma A. The escalating antibiotic crisis in Nigeria: A violation of human rights and ethical imperatives – Commentary. Ann Public Health Res 2024;11:1-3.
47. Torres NF, Chibi B, Kuupiel D, Solomon VP, Mashamba-Thompson TP, Middleton LE. The use of non-prescribed antibiotics; prevalence estimates in low-and-middle-income countries. A systematic review and meta-analysis. Arch Public Health 2021;79:2.
48. Auta A, Hadi MA, Oga E, Adewuyi EO, Abdu-Aguye SN, Adeloye D, *et al*. Global access to antibiotics without prescription in community pharmacies: A systematic review and meta-analysis. J Infect 2019;78:8-18.
49. Nepal G, Bhatta S. Self-medication with antibiotics in WHO Southeast Asian Region: A systematic review. Cureus 2018;10:e2428.
50. Saleem Z, Hassali MA, Godman B, Fatima M, Ahmad Z, Sajid A, *et al*. Sale of WHO AWaRe groups antibiotics without a prescription in Pakistan: A simulated client study. J Pharm Policy Pract 2020;13:26.
51. Abdullah S, Saleem Z, Godman B, Hashmi FK, Haseeb A, Al-Rawi MB, *et al*. Surge of branded generics and antimicrobial resistance: Analyzing the antibiotic market dynamics in Pakistan through the WHO essential medicines and AWaRe lens. Expert Rev Anti Infect Ther 2025;23:513-21.
52. Abdullah S, Saleem Z, Godman B. Coping with increasing medicine costs through greater adoption of generic prescribing and dispensing in Pakistan as an exemplar country. Expert Rev Pharmacoecon Outcomes Res 2024;24:167-70.
53. Godman B, Fadare J, Kwon HY, Dias CZ, Kurdi A, Dias Godói IP, *et al*. Evidence-based public policy making for medicines across countries: Findings and implications for the future. J Comp Eff Res 2021;10:1019-52.
54. Omape A. Fake Drugs Kill Thousands, Yet Offenders Walk Free – Pharmaceutical Society President, Ayuba; 2025. Available from: https://punchng.com/fake-drugs-kill-thousands-yet-offenders-walk-free-pharmaceutical-society-president-ayuba/. [Last accessed on 2025 May 30].
55. Duffy E, Ritchie S, Metcalfe S, Van Bakel B, Thomas MG. Antibacterials dispensed in the community comprise 85%-95% of total human antibacterial consumption. J Clin Pharm Ther 2018;43:59-64.
56. Dixon J, MacPherson EE, Nayiga S, Manyau S, Nabirye C, Kayendeke M, *et al*. Antibiotic stories: A mixed-methods, multi-country analysis of household antibiotic use in Malawi, Uganda and Zimbabwe. BMJ Glob Health 2021;6:e006920.
57. Sono TM, Yeika E, Cook A, Kalungia A, Opanga SA, Acolatse JE, *et al*. Current rates of purchasing of antibiotics without a prescription across Sub-Saharan Africa; rationale and potential programmes to reduce inappropriate dispensing and resistance. Expert Rev Anti Infect Ther 2023;21:1025-55.
58. Wada YH, Abdulrahman A, Ibrahim Muhammad M, Owanta VC, Chimelumeze PU, Khalid GM. Falsified and substandard medicines trafficking: A wakeup call for the African continent. Public Health Pract 2022;3:100240.
59. Zabala GA, Bellingham K, Vidhamaly V, Boupha P, Boutsamay K, Newton PN, *et al.* Substandard and falsified antibiotics: Neglected drivers of antimicrobial resistance? BMJ Glob Health 2022;7:e008587.
60. Asrade Mekonnen B, Getie Yizengaw M, Chanie Worku M. Prevalence of substandard, falsified, unlicensed and unregistered medicine and its associated factors in Africa: A systematic review. J Pharm Policy Pract 2024;17:2375267.
61. Tegegne AA, Feissa AB, Godena GH, Tefera Y, Hassen HK, Ozalp Y, *et al*. Substandard and falsified antimicrobials in selected East African countries: A systematic review. PLoS One 2024;19:e0295956.
62. Feeney AJ, Goad JA, Flaherty GT. Global perspective of the risks of falsified and counterfeit medicines: A critical review of the literature. Travel Med Infect Dis 2024;61:102758.
63. Waffo Tchounga CA, Sacré PY, Ciza Hamuli P, Ngono Mballa R, Nnanga Nga E, Hubert P, *et al*. Poor-quality medicines in Cameroon: A critical review. Am J Trop Med Hyg 2021;105:284-94.
64. Sudhinaraset M, Ingram M, Lofthouse HK, Montagu D. What is the role of informal healthcare providers in developing countries? A systematic review. PLoS One 2013;8:e54978.
65. Liow E, Kassam R, Sekiwunga R. How unlicensed drug vendors in rural Uganda perceive their role in the management of childhood malaria. Acta Trop 2016;164:455-62.
66. Gautham M, Miller R, Rego S, Goodman C. Availability, prices and affordability of antibiotics stocked by informal providers in rural India: A cross-sectional survey. Antibiotics 2022;11:523.
67. Rousham EK, Nahar P, Uddin MR, Islam MA, Nizame FA, Khisa N, *et al*. Gender and urban-rural influences on antibiotic purchasing and prescription use in retail drug shops: A one health study. BMC Public Health 2023;23:229.
68. Ferdiana A, Liverani M, Khan M, Wulandari LP, Mashuri YA, Batura N, *et al*. Community pharmacies, drug stores, and antibiotic dispensing in Indonesia: A qualitative study. BMC Public Health 2021;21:1800.
69. Macé C, Nikiema JB, Sarr OS, Ciza Hamuli P, Marini RD, Neci RC, *et al*. The response to substandard and falsified medical products in francophone Sub-Saharan African countries: Weaknesses and opportunities. J Pharm Policy Pract 2023;16:117.
70. Kniazkov S, Dube-Mwedzi S, Nikiema JB. Prevention, detection and response to incidences of substandard and falsified medical products in the member states of the Southern African development community. J Pharm Policy Pract 2020;13:71.
71. Abdulwahab AA, Okafor UG, Adesuyi DS, Miranda AV, Yusuf RO, Eliseo Lucero-Prisno D 3rd. The African medicines agency and medicines regulation: Progress, challenges, and recommendations. Health Care Sci 2024;3:350-9.

72. Ndomondo-Sigonda M, Miot J, Naidoo S, Masota NE, Ng'andu B, Ngum N, *et al*. Harmonization of medical products regulation: A key factor for improving regulatory capacity in the East African community. BMC Public Health 2021;21:187.
73. NAFDAC. Public Alert No. 020/2024 – Alert on Confirmed Falsified OHEAL Ampicillin and Cloxacillin Capsule; 2024. Available from: https://nafdac.gov.ng/public-alert-no-020-2024-alert-on-confirmed-falsified-oheal-ampicillin-and-cloxacillin-capsule/. [Last accessed on 2025 May 10].
74. Interpol. Crackdown on Illicit Health and Counterfeit Products Identifies 179 Suspects in Southern Africa; 2021. Available from: https://www.interpol.int/en/News-and-Events/News/2021/Crackdown-on-illicit-health-and-counterfeit-products-identifies-179-suspects-in-Southern-Africa. [Last accessed on 2025 May 10].
75. Interpol. Pharmaceutical Crime: First INTERPOL-AFRIPOL Front-Line Operation Sees Arrests and Seizures Across Africa; 2022. Available from: https://www.interpol.int/en/News-and-Events/News/2022/Pharmaceutical-crime-first-INTERPOL-AFRIPOL-front-line-operation-sees-arrests-and-seizures-across-Africa. [Last accessed on 2025 May 11].
76. Interpol. Pharmaceutical Crime Operations – Pharmaceutical Crime; 2022. Available from: https://www.interpol.int/Crimes/Illicit-goods/Pharmaceutical-crime-operations. [Last accessed on 2025 May 10].
77. Nori L, Varma T, Nulu L, Raju K. A study of regulations combating counterfeit medicines across India, USA, and Europe. Asian J Pharm Res Health Care 2023;15:115.
78. Cadwallader AB, Nallathambi K, Ching C. Why assuring the quality of antimicrobials is a global imperative. AMA J Ethics 2024;26:E472-8.
79. BOMRA. Transitioning to Maturity Level 3 – 2022/2023 ANNUAL REPORT. Available from: https://www.bomra.co.bw/downloads/#51-119-wpfd-annual-reports-1657024402. [Last accessed on 2025 May 10].
80. Pragi AJ, Kumar Varun M. Counterfeit medicine in India: Are we heading in the right direction at the desired pace? Int J Pharm Qual Assur 2024;15:2630-9.
81. Pathak R, Gaur V, Sankrityayan H, Gogtay J. Tackling counterfeit drugs: The challenges and possibilities. Pharmaceut Med 2023;37:281-90.
82. Singh A. Combating counterfeit and substandard medicines in India: Legal framework and the way ahead. Curr Res J Soc Sci 2023;6:101-11.
83. Sutaria I. Anti-Counterfeit Pharmaceutical Packaging Market Outlook for (2023 to 2033); 2023. Available from: https://www.futuremarketinsights.com/reports/anti-counterfeit-pharmaceutical-packaging-market. [Last accessed on 2025 May 10].
84. WHO. Substandard and Falsified Medical Products; 2024. Available from: https://www.who.int/news-room/fact-sheets/detail/substandard-and-falsified-medical-products.[Last accessed on 2025 May 11].

Access this article online	
Quick Response Code:	Website: www.aihbonline.com
	DOI: 10.4103/aihb.aihb_132_25

How to cite this article: Munzhedzi M, Kumar S, Godman B, Meyer JC. Potential ways to improve the supply and use of quality-assured antibiotics across sectors in developing countries to reduce antimicrobial resistance. Adv Hum Biol 0;0:0.