An analysis of existing national action plans for antimicrobial resistance—gaps and opportunities in strategies optimising antibiotic use in human populations

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At the 2015 World Health Assembly, UN member states adopted a resolution that committed to the development of national action plans (NAPs) for antimicrobial resistance (AMR). The political determination to commit to NAPs and the availability of robust governance structures to assure sustainable translation of the identified NAP objectives from policy to practice remain major barriers to progress. Inter-country variability in economic and political resilience and resource constraints could be fundamental barriers to progressing AMR NAPs. Although there have been regional and global analyses of NAPs from a One Health and policy perspective, a global assessment of the NAP objectives targeting antimicrobial use in human populations is needed. In this Health Policy, we report a systematic evidence synthesis of existing NAPs that are aimed at tackling AMR in human populations. We find marked gaps and variability in maturity of NAP development and operationalisation across the domains of: (1) policy and strategic planning; (2) medicines management and prescribing systems; (3) technology for optimised antimicrobial prescribing; (4) context, culture, and behaviours; (5) operational delivery and monitoring; and (6) patient and public engagement and involvement. The gaps identified in these domains highlight opportunities to facilitate sustainable delivery and operationalisation of NAPs. The findings from this analysis can be used at country, regional, and global levels to identify AMR-related priorities that are relevant to infrastructure needs and contexts.

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Introduction

Systematic analysis has estimated the current burden of bacterial antimicrobial resistance (AMR) to be potentially larger than many major diseases (eg, HIV and malaria), with highest rates expected in sub-Saharan Africa.[1] Formulating and sustaining an effective global response to this AMR pandemic has substantial challenges, including resource inequity, implementation gaps and failures, and issues around drug and diagnostic development market forces.[2–4] Recognising the need for global agreement and concerted change, WHO developed a Global Action Plan to guide AMR strategy development and interventions to optimise diagnosis, management, and surveillance of infectious diseases and drug-resistant infections.[5] WHO has provided a framework for countries to identify progress indicators and implement monitoring and evaluation of AMR strategies.[6,7] Although individual countries have committed to developing national action plans (NAPs), their mere existence is not enough.[8]

The purpose of an NAP, as defined by WHO, is to (1) improve understanding and awareness of AMR; (2) strengthen the evidence base through surveillance and research; (3) reduce incidence of infections through water sanitation and hygiene, and infection prevention and control; (4) optimise use of antimicrobials in human and animal health; and (5) increase investment in diagnostics, new medicines, vaccination, and other interventions.[5] The operationalisation of NAP objectives into meaningful and impactful change at country level needs to be supported by evidence-based policy and evaluation. Although there was a review of WHO approved NAPs by Willemsen and colleagues,[9] which investigated existing NAPs' alignment with the One Health agenda and highlighted policy gaps, an evaluation of the progress of NAPs in relation to human health and AMR has not yet been performed.

We conducted an evidence synthesis of available NAPs identifying gaps and opportunities to strengthen strategies for optimising antibiotic use in human populations. NAPs were analysed using a previously established framework covering six domains.[2] Changes in health-care provision arising from the COVID-19 pandemic,[10,11] and the imminent timeline for countries to develop the next iteration of their NAPs, make this review and its recommendations relevant and of immediate use, helping identify new objectives and align needed actions.

Methods

NAP search strategy and retrieval

We conducted a targeted literature review of NAPs in countries listed according to the Organisation for Economic Co-operation and Development (OECD) income index classification (ie, high income, middle income, low income, and least developed). Information on NAP and AMR progress was retrieved from the global database for the tripartite AMR country self-assessment survey.[12] Existing NAPs were retrieved from the WHO library. For countries not listed, an internet search was done to identify whether an NAP was available in any national databases. For NAPs not in English, an internet search was performed to identify if an English version was available. We were able to find English translations

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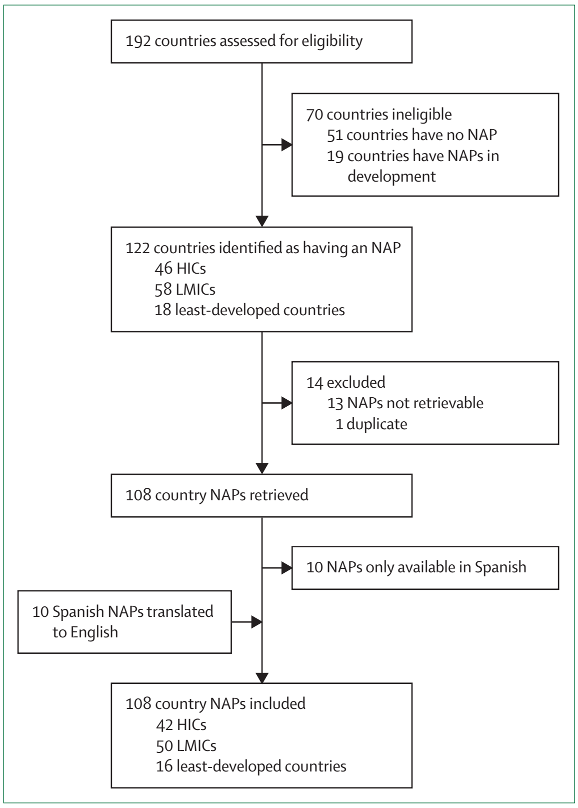

Figure 1: **Flow diagram of search and retrieval of country NAPs for inclusion in the analysis**
NAP=national action plan. LMIC=low-income and middle-income country.

of NAPs in Arabic, French, Chinese, and Russian. Due to the high number of NAPs from Spanish speaking countries without an English version, the Spanish NAPs were reviewed by a Spanish speaking coauthor (VA-V). The initial search was performed in March, 2021 and repeated in February, 2022.

Qualitative data extraction and coding

We previously identified six key domains to assist optimising antimicrobial use in humans through international consensus with interdisciplinary experts using round-table discussions and two surveys, the details of which are published[2] and are provided in the appendix (pp 2–5). The domains were: (1) policy and strategic planning; (2) medicines management and prescribing systems; (3) technology for optimised antimicrobial prescribing and use; (4) context, culture, and behaviours; (5) operational delivery and monitoring; and (6) patient and public engagement and involvement. These domains were used to develop a framework for data extraction (appendix p 6). Operational delivery measured any evidence of economic investment in delivering the NAP objectives and recognition of integrating infection prevention and control. Data extraction was through line-by-line content analysis. Five researchers (EC, CB, SJCP, OM, and VN) reviewed NAPs, with one researcher (EC) reviewing all extracted data to ensure consistency, including cross-checking extracted data against NAP documents. Coding was iterative, with constant reassessment of coded data to cross-check for inter-rater reliability. QSR NVivo (version 12) was used to code, organise, and share data among all coauthors. The findings were discussed among all coauthors, after which content analysis was refined to ensure completeness of coding.[13]

See Online for appendix

Antimicrobial resistance and consumption analysis

We identified comparable data for a small number of countries on antibiotic consumption from the WHO report on Surveillance of Antibiotic Consumption.[14] Additionally we reviewed the WHO Global Antibiotic Surveillance System (GLASS) database for any data on AMR or antibiotic consumption submitted from countries included in this review. Descriptive statistics were used to conduct a secondary analysis of the relationship between antibiotic consumption, NAP availability, and region in statistical package for the social sciences. Variation in the descriptive variables was assessed using χ^2 test. Statistical significance was defined as a $p \leq 0 \cdot 05$.

Results

NAP analysis across the six domains

122 (64%) of 192 countries were identified as having an NAP (figure 1)—ie, 46 (84%) of 55 high-income countries (HICs), 58 (61%) of 95 low-income and middle-income countries (LMICs), and 18 (43%) of 42 least-developed countries. Of these, 13 were not retrievable and one was a duplicate (Eswatini and Swaziland). As of Feb 28, 2022, one country had a national strategy and two countries had produced version two of their NAP.

108 NAPs were, therefore, reviewed (table 1), 42 (39%) from HICs, 50 (46%) from LMICs, and 16 (15%) from least-developed countries. The earliest NAP identified was from Greece (starting in 2008), with most being published between 2011 and 2021. NAP availability by WHO region is summarised in figure 2.

Policy and strategic planning

Technical support from external organisations for NAP development was stated in 18 NAPs, all of which were LMICs. Egypt, Fiji, Ghana, Indonesia, Lebanon, Maldives, Federated States of Micronesia, Nepal, Pakistan, Peru, Philippines, Sierra Leone, Sri Lanka, Sudan, Tanzania, and Zimbabwe reported technical support from WHO.[15–30] Assistance from other organisations was as follows: the US Agency for International Development (Eswatini), Centre for Disease Dynamics Economics and Policy (Uganda), and India Centre for Science and Environment (Zambia).[31–33] The Afghanistan NAP, shows a heavy reliance on non-governmental organisations including WHO, UN Environmental Programme, and UNICEF for the delivery of the specific objectives identified.[34]

	Policy and strategic planning	Medicines management and prescribing systems	Technology for optimised antimicrobial prescribing and use	Context, culture, and behaviours	Operational delivery and monitoring*	Operational delivery and monitoring†	Operational delivery and monitoring‡	Patient and public engagement and involvement§	Patient and public engagement and involvement¶	Recognition of infection prevention and control measures as part of the strategy to deliver the NAP objectives
High-income countries (n=42)	38 (90%)	33 (79%)	19 (45%)	18 (43%)	27 (64%)	34 (81%)	27 (64%)	21 (50%)	39 (93%)	42 (100%)
LMICs (n=50)	50 (100%)	45 (90%)	24 (48%)	29 (58%)	39 (78%)	44 (88%)	36 (72%)	22 (44%)	44 (88%)	50 (100%)
Least-developed countries (n=16)	16 (100%)	15 (94%)	5 (31%)	11 (69%)	15 (94%)	14 (88%)	15 (94%)	8 (50%)	16 (100%)	16 (100%)

Data are n/N (%). LMIC=low-income and middle-income country. NAP=National action plan. *Information about capacity developed or planned to deliver the NAP objectives. †Situational analysis of country capability and capacity is to deliver the NAP objectives. ‡Evidence of monitoring and evaluation against the NAP deliverables. §Reference to the role of patient engagement. ¶Reference to the role of the public engagement.

Table 1: **The proportion of the NAPs reviewed that include details of the overarching domains included in the framework**

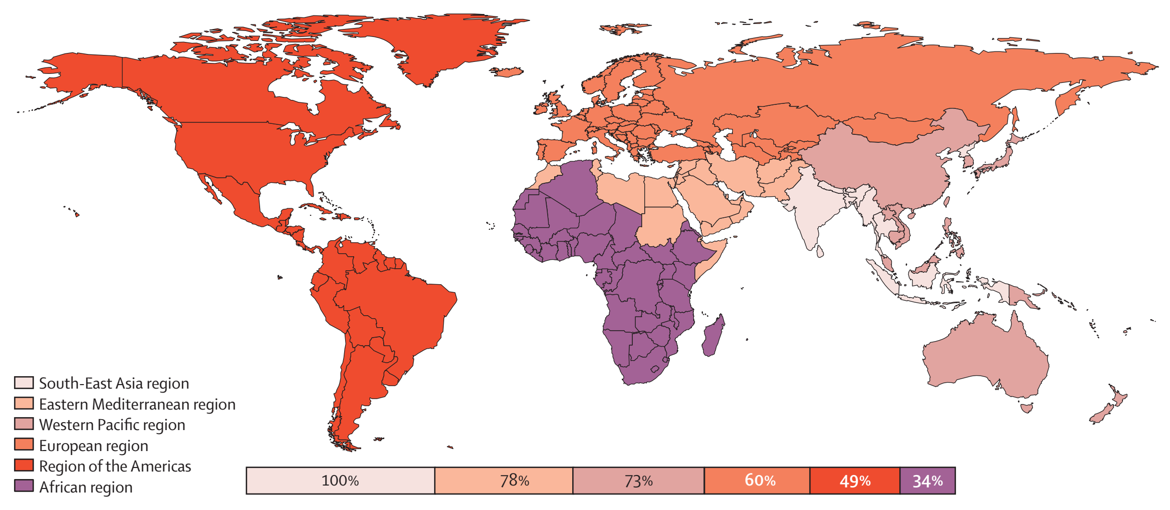

Figure 2: **Availability of national action plans by WHO region as of February, 2022**

Political endorsement is evident in all NAPs. The Ministry of Health or equivalent for each country was included as a key signatory in all NAPs. Beyond ministerial endorsement, NAPs from Bahrain and Tanzania included clearly identified individuals within the political and financial structure who were named as accountable individuals for the successful delivery of the NAP objectives.[29,35]

One Health perspective was identified in 87 (81%) of 108 country NAPs—ie, 35 (83%) of 42 HICs, 36 (72%) of 50 LMICs, and 16 (100%) of 16 least-developed countries. The need for new legislation or enforcing of existing legislation was stated in 98 (91%) of 108 country NAPs—ie, 36 (86%) of 42 HICs, 47 (94%) of 50 LMICs, and 15 (94%) of 16 least-developed countries. Although the focus is predominantly on regulating access to antibiotics, there is little information on the type of legislation or actionable steps needed. There are common gaps across many NAPs around defining the current human resource capacity to deliver stated objectives, financial commitment to facilitate successful implementation, and measurable indicators to evaluate outcomes. The Kenya NAP was identified as a positive outlier demonstrating a comprehensive, multisectoral, and stakeholder-led approach to developing and evaluating NAP in AMR (appendix p 7).[36] Delivery and monitoring of the Kenya NAP is supported by a governance framework that operates at the national and regional (county) level across multisectoral government agencies and recognises the human resources needed.

Medicines management

Submission of AMR surveillance data to the GLASS database was mentioned in 41 (38%) of 108 NAPs—ie, 12 (29%) of 42 HICs, 21 (42%) of 50 LMICs, and

	NAP available and included in this review	NAPs that mentioned submission of AMR data to GLASS database*	AMR data available in GLASS database*	Antibiotic use or consumption data available in the NAPs*†	Antibiotic consumption data available in WHO report‡	Range; mean (median) antibiotic consumption reported as defined daily doses per 1000 population (p=0·061)‡
High-income countries (n=55)	42 (76%) of 55	12 (29%) of 42	29 (69%) of 42	16 (38%) of 42	32 (58%) of 55	9·78–33·85; 19·29 (17·91)
LMICs (n=95)	50 (53%) of 95	21 (42%) of 50	18 (36%) of 50	18 (36%) of 50	26 (27%) of 95	5·29–64·41; 19·86 (17·67)
Least-developed countries (n=42)	16 (38%) of 42	8 (50%) of 16	11 (69%) of 16	3 (19%) of 16	4 (10%) of 42	4·44–27·29; 16·44 (17·02)

Data are n/N(%). All 192 countries were categorised by OECD classification. AMR=antimicrobial resistance. GLASS=Global Antimicrobial Use and Surveillance System. LMIC=low-income and middle-income country. NAP=National action plan. OECD=Organisation for Economic Co-operation and Development. *Data reviewed from the 108 countries with NAPs included in this review. †The antibiotic use or consumption data in the NAPs were not consistent in their representation, often drawing data from small populations or a single study, and, therefore, could not be evaluated. ‡Antibiotic consumption data were retrieved for secondary analysis from an existing WHO AMR report published in 2019, with data available for 63 countries.[14] The consumption data in this report were presented as defined daily doses per 1000 population.

Table 2: **Antibiotic consumption data and AMR surveillance data and their submission to GLASS database for the countries with an NAP that were included in this review**

eight (50%) of 16 least-developed countries (table 2). AMR data are available from the GLASS database for 58 (54%) of 108 countries—ie, 29 (69%) of 42 HICs, 18 (36%) of 50 LMICs, and 11 (69%) of 16 least-developed countries. There were scarce antibiotic use data available in 37 (34%) of 108 NAPs—ie, 16 (38%) of 42 HICs, 18 (36%) of 50 LMICs, and three (19%) of 16 least-developed countries (table 2).

Although the commitments to invest in uninterrupted antimicrobial supply, management, and procurement systems were identified as objectives in 24 (22%) of 108 NAPs—ie, five (12%) of 42 HICs, 16 (32%) of 50 LMICs, and three (19%) of 16 least-developed countries—these were not followed through with explicit political or financial commitment to deliver the objectives. In relation to supply chain strengthening, there are no strategies proposed for dealing with medication access and shortages in any NAPs.

When NAPs discuss the need for quality, safety, and pharmacovigilance of antibiotics, they do not articulate strategies for meeting these needs. Research and development for new drugs are included in three NAPs as areas that need strengthening; however, it is not clear why these are in the NAPs, as the governments have little influence over the research and development of new drugs. The absence of government influence brings into question the relevance of having new drug development as an objective in NAPs, and how it can be translated into deliverable and measurable actions with the 5-year life span of the NAPs.

Technology and diagnostics

Although most of the innovation in regard to AMR is driven by research, this is overlooked in the NAPs, with no strategic evidence of how to scale up targeted research and innovation to better understand how successful technologies can be adopted and appropriately adapted for different settings. There is no evidence of the economic analysis of technology implementation or the need for retraining staff in any NAP.

Diagnostics, including point-of-care diagnostics, are identified as potential enablers of successful outcomes in the management of infections in 28 (26%) of 108 NAPs, but the contextual and economic evaluation of their usability and appropriateness to context in different settings is not clearly identified. Crucially, beyond the situational analyses of the prevalence of AMR and drug-resistant infections, the NAPs make no effort to develop strategies for using existing infrastructure or data to measure the effect of technological solutions.

Patient and public engagement

All 16 least-developed country NAPs included consideration for the role of the public in managing AMR. Patient safety was discussed in two NAPs as an outcome indicator of success. Public education (including in diverse places such as schools and undergraduate teaching) was recognised as the main means of raising awareness of AMR in all but five NAPs; however, very few strategic pathways to achieving awareness were identified. The efforts to raise awareness are predominantly channelled through education and teaching including using social media and news platforms. Addressing patient demands for antibiotics and the need to educate them on this subject are mentioned in three NAPs but are not followed through with a strategy for evaluation. Furthermore, there is no evidence provided of learning from other within-country strategies or global public health strategies that could have been successful.

Context, culture, and behaviours

Behavioural change was a recognised objective in 34 (31%) of 108 NAPs, predominantly in the context of public education and awareness campaigns with little recognition of the need for behavioural change among health-care workers. No NAPs acknowledge the need to tailor messages to different audiences. There is little to no recognition of the need for addressing cultural drivers of health-seeking and health-providing behaviours, which affect the management of drug-resistant infections and patient outcomes. The failure to account for cultural and contextual drivers is a substantial gap as we need to move away from a one-size-fits-all approach to implementing NAPs. Contextualising the interventions aiming to optimise antibiotic use in human populations is a fundamental piece of the puzzle to delivering NAPs in a sustainable and impactful way.

Other recognised priorities

Generally, disparities in available human resources within countries across rural, urban, and public and private sectors are not discussed in NAPs, except for in Iran. Iran's NAP has a matrix of internal and external factors that would affect the delivery of the objectives in the NAP, including scarcity of human resources.[37] This avoidance overlooks the mismatch between expectations of success and the real-world national challenges of delivering to NAP objectives developed from a global template. Furthermore, this might also reflect the gaps in research capacity to support the delivery of NAP objectives in efforts to respond to the threat of AMR.

There are disparities in the detail and strength of monitoring and evaluation plans. Oman,[38] Bahrain,[35] and Kenya[36] have developed milestones with funding assigned. The linking of realistic timelines to achieve identified objectives, and a strategy for transparent and centralised mechanisms for monitoring progress, is missing. The most crucial gap is the absence of measurable indicators to monitor progress.

Immunisation and the need for strengthening vaccination programmes, including awareness about the need for vaccination, is in 14 (13%) of 108 NAPs, from both HICs and LMICs. Although all NAPs recognised the need for implementing effective infection prevention and control strategies as part of the response to AMR, no measurable metrics monitoring progress on this were provided.

Triangulation of medicines management domain with available AMR and consumption data

Comparable data across countries on antibiotic consumption are available from 62 countries via WHO—ie, 32 (58%) of 55 HICs, 26 (27%) of 95 LMICs, and four (10%) of 42 least-developed countries (table 2).[14] Overall, 48 (42%) of 115 of countries with NAPs and 21 (28%) of 75 of countries with no NAP have comparable antibiotic use data. Burundi reports the lowest antibiotic consumption (four defined daily doses per 1000 population) and Mongolia, an outlier, the highest (64·1 defined daily doses per 1000 population). The second highest consumers are Iran and Türkiye (38 defined daily doses per 1000 population). The mean defined daily doses per 1000 population for HICs was 19·29 (SD 5·76, median 17·91, IQR 8·86). For LMICs the mean defined daily doses per 1000 population was 17·86 (SD 12·79, median 17·67, IQR 12·97). For least-developed countries the mean defined daily doses per 1000 population was 16·44 (SD 9·72, median 17·02, IQR 10·57). There was no statistically significant difference between OECD category of countries and antibiotic consumption, in the data available (p=0·061). When classified by WHO region, the Western Pacific region reported the lowest regional rates of antibiotic consumption compared with the European region, which reported the highest regional rates of antibiotic consumption (p=0·029). Having an NAP was not associated with a reduced reported rate of antibiotic consumption (p=0·74).

Discussion

In this Health Policy paper, we present an empirical evidence synthesis of existing NAPs providing knowledge on current gaps and opportunities for strategies to optimise antibiotic use in human populations. On the basis of these findings we have summarised the key strategic opportunities that countries can consider in their efforts to manage the threat of AMR (table 3). The level and strength of commitment to the NAP as well as the capacity of individual countries to develop NAP objectives will be integral to their delivery. To harness political engagement and commitment, NAPs need to include objectives that evaluate the economic effect of strategies implemented to optimise antibiotic use in human populations in different countries. There needs to be a clear governance framework for effective development and delivery of NAPs.[39] The ability to progress from paper to action requires governments, policy makers, and stakeholders to have clearly defined roles that are backed by financial commitment and political power to deliver objectives and review achievements.

Robust, locally led strategies are needed to identify targeted and sustainable indicators to track antibiotic use, AMR, and infection prevention and control. Where data already exist, they illustrate that having an NAP alone is not indicative of robust surveillance or optimised antibiotic use. Furthermore, existing data highlight the limitations of categorising countries into HIC versus LMIC, and the need for assessment of existing prescribing tools across the health-care system (from community to hospital care) to enable a review of capabilities for optimum prescribing and surveillance. NAP objectives and AMR-related interventions and research are typically developed using evidence and standards generated in HICs, whose health resources and infrastructure face different challenges to those in LMICs. This difference is reflected in our current findings, in which we found clear disparities between the intent to submit surveillance data to GLASS and those countries—considerably weighted towards HICs—that were actually able to submit regular data. This disparity is further reflected by the latest tripartite AMR country self-assessment survey results in which three LMICs or least-developed countries

	Example	Opportunities for addressing challenges as part of effective and sustainable efforts to manage AMR
Policy and strategic planning		
Scarce evidence of political commitment and mechanisms to mobilise plans	The evidence of political commitment was present through the multisectoral ministerial endorsement of the NAPs; within this, roles and responsibilities of individuals or national focal points were only present in a few selected NAPs; there was little explicit mention of executive power for introducing high-level decisions and policies	Conduct economic impact assessment of the strategies implemented to tackle AMR and the resource and infrastructure requirements as a tool for gaining political and financial commitment; define how NAPs were developed, (eg, by local stakeholders or external consultants as an indicator of the level of internal capacity, ownership, commitment, and measure of sustainability)
Little rationale for use or not of legislation to support NAP objectives	The introduction of new legislation and strengthening of existing legislation for the appropriate and rational use of antibiotics was discussed in most NAPs	Investigate how existing laws can be enforced, and appropriateness of new legislation developed to facilitate legitimate, equitable access to quality-assured antibiotics
Little governance of NAP delivery	Some countries have identified a combination of intersectoral committees, technical advisory groups, core working groups, and monitoring groups to provide governance for the delivery of the NAP objectives	Investigate how existing laws can be enforced, and appropriateness of new legislation developed to facilitate legitimate, equitable access to quality-assured antibiotics
Development of national, regional, and local antibiotic policies	This was the most consistently discussed feature across all the NAPs reviewed	Identify universal indicators and investigate how to sustainably collect data over time to monitor progress of interventions aiming to optimise antibiotic use in human populations
Strengthening surveillance as a strategy for infection prevention and control and AMR containment	Although the need for surveillance was recognised across all NAPs—the mechanisms for achieving sustained surveillance were not clearly defined	Identify a clear strategy for delivering sustainable surveillance, through existing capacity and potential for innovation; where capacity is lacking, develop an economically and strategically viable plan for delivering a surveillance programme that is fit to the national context and need
Ineffective or complete absence of data sharing with policy makers and managers	There is a difficulty in communicating, disseminating, and translating the results of research to inform policies and programmes	Adopt knowledge mobilisation methodologies that emphasise exchange between producers and users of evidence iteratively; acknowledge the different dimensions of AMR at different levels of policy making, and use relevant solutions informed by implementation studies
Medicines management		
Scarcity of robust medication supply chains	Investment in uninterrupted antibiotic supply, management, and procurement systems; enforcement of legislation for appropriate antibiotic access and use	Assess existing prescribing tools across the health-care system (from community to hospital care), to enable a review of capabilities for optimum prescribing and surveillance of prescribing and consumption; identify mechanisms for data sharing on supply chain issues at local, national, and international level; develop and evaluate strategies to enforce antibiotic prescribing, purchase, and access-related legislation; identify opportunities for local production of antibiotics and addressing the issues with voluntary licensing
Technology and diagnostics		
No universal access to diagnostics	The need for development and implementation and improved access to diagnostics, including rapid point of care diagnostics was an objective across several NAPs	Investigate the whole-health-system integration of technologies
Little effective use of information technology for data linkage	Harnessing the existing data through better use of information technology and data linkage was discussed in a small number of NAPs	Identify affordable and sustainable access to innovation; assess cost and clinical effectiveness of technologies; develop strategies for maximising the use of existing data to develop a means to measure effect
Inconsistent laboratory capacity	Prioritising the need for consistent access to laboratory infrastructure; the need for strengthening medical microbiology capacity to support diagnostic capabilities were discussed and linked to the need for developing technology and diagnostics	Investigate the role of diagnostics in different contexts to introduce technologies that meet local needs and capacity; develop training mechanisms for staff in technology and diagnostics
Patient and public engagement		
Patients recognised as lesser stakeholders	The extent of patient roles in NAPs, when they did appear, focused on managing demand for antibiotic use and raising awareness on AMR; however, there were not clearly defined strategies for how to manage demand and raise AMR awareness in most NAPs; health literacy and health-related knowledge as contributors to antibiotic-related behaviours featured in just one NAP	Develop a strategy for assessing attitudes, behaviours, and practices across socioeconomically and culturally diverse populations to facilitate broad reach of interventions and public health campaigns
Reinforcement of public health education campaigns	A range of awareness campaigns are included in the NAPs spanning outreach programmes to schools, universities, and in social and traditional media; use of public surveys to canvas existing beliefs and attitudes was also discussed in a few NAPs	Learn lessons from other national policies that have benefited from a more inclusive approach in terms of social participation (public engagement) and active role of the public and patients in implementation; each country might have their own successful examples, there are experiences with other agenda-setting processes in which the public were included early at the inception of policy formation (eg, tuberculosis and HIV)

(Table 3 continues on next page)

compared with 19 HIC respondents submitted antibiotic use data.[12] To help benchmark data in a better manner, categorisations of countries are needed beyond labelling them as low-resource settings,[40] especially when analysing and evaluating interventions and innovations in AMR. Additionally, access to quality-assured medicines and strengthening mechanisms to deal with antibiotic shortages are key components of medicines management, particularly in the context of other health crises, such as the current COVID-19 pandemic and the post-pandemic

	Example	Opportunities for addressing challenges as part of effective and sustainable efforts to manage AMR
(Continued from previous page)		
Culture and context		
Promotion of behaviour change among prescribers and the wider community	Overall, there is little recognition of the need to develop strategies and interventions that are context appropriate; conducting surveys and promoting awareness through education were the most recurring means of understanding and changing behaviours in the NAPs	Investigate the prevailing power dynamics and identify key stakeholders to drive NAP development and co-design objectives and interventions
Understanding the behavioural drivers for AMR	A need to tailor messaging and the recognition of the need to understand sociocultural drivers for attitudes and behaviours was evident in a few NAPs	Investigate the effect of sociocultural drivers, including gender, race, and ethnicity, on antibiotic use in different populations and develop contextually appropriate interventions to influence health-seeking and health-providing behaviours
Other recognised priorities in NAPs		
Vaccination as an important measure in preventing infections (included in 14 NAPs)	Vaccination programme strengthening was recognised as an intervention to support efforts tackling AMR; a need for implementing campaigns supporting vaccination uptake; a need for research and development into new vaccines and alternatives	Investigate how to develop a strategy for implementing sustainable vaccination campaigns that target those least likely to be vaccinated; conduct research to investigate how to increase vaccine uptake in health-care worker populations as well as populations with socioeconomic disadvantages
Research to support the delivery of NAP objectives	Research in AMR to assist policy setting in AMR and resource allocation was recognised in a few of the NAPs; the translation of research into practice and the development of a national research agenda to tackle AMR were mentioned in a small number of NAPs; NAPs indicated the intention to conduct knowledge, attitude, practice, and behavioural research across both professional and social groups as a baseline to support AMR mitigation and antimicrobial stewardship implementation efforts; NAPs identified the need for research and development into new antibiotics and therapeutics	Develop a national and international research strategy aligned with NAP objectives to tackle AMR through multisector, interdisciplinary, and international research; identify mechanisms for linkage of the research strategy to funding through political commitment and investment; develop a strategy for mobilising research to action at scale, with measured impact, through engagement with policy makers

NAP=National action plan. AMR=antimicrobial resistance.

Table 3: **The strategic gaps and opportunities in key domains of NAPs for optimising antibiotic use in human populations**

climate in which resources, both financial and human, are more scarce.[41]

No NAPs fully consider the complexity of care pathways and health systems in which innovations and diagnostics are to be implemented.[42] As diagnostic scope and availability are intertwined with antibiotic use and the design of antimicrobial stewardship guidelines, the strategies to support sustainable delivery of NAPs need to be tailored to the real-world, national contextual needs and the political and economic environment.[43] One essential step towards making these individualised modifications might be through individual country assessment for AMR control preparedness by use of, for example, the WHO Joint External Evaluation Tool for International Health Regulations.[44] Failing to address these real-world, national contextual needs feeds into the underlying inequities in access to diagnostics between HICs and LMICs.[45–47] Likewise, for surveillance of AMR and antibiotic use, to understand the capacity for data collection and surveillance, the scarcity of available data highlighted here and elsewhere shows that there first needs to be a situational analysis of the existing capability and capacity of systems to deliver prescribing and consumption data.[1]

The role of the private sector in providing data to support AMR surveillance, antibiotic use, and optimisation of current practices has been underused. Research that investigates whole-health-system integration of technology and innovation is needed, by maximising the use of existing data and by understanding its current limitations.[3] This approach could be of particular use when countries are considering entering into public–private surveillance partnerships.[48]

Patient and general public engagement in AMR efforts is largely overlooked in NAPs. Moving beyond raising awareness, there needs to be greater efforts to evaluate public health strategies and their effectiveness in communicating in a meaningful and impactful way with the public, carers, and patients. Strategies are needed for assessing attitudes, behaviours, needs, and practices across socioeconomically and culturally diverse populations to facilitate broad reach of interventions and public health campaigns. This crucial gap in the NAPs is a reflection of wider gaps within the AMR environment and hinders reach to diverse populations, including those most clinically vulnerable to the threat of drug-resistant infections.[49]

Limitations

Our analysis is restricted by our ability to review only readily available NAPs in English and Spanish, retrieved via the methods described, at the time it was conducted. NAPs have a timeline of 5 years so we recognise that an updated review is now due for most NAPs—ie, 76 (70%) of 109 available NAPs. WHO provide an online library for repositing current NAPs, but this is not consistently updated, making some NAPs difficult to locate. This outdated library does, however, strengthen the potential value of our structured synthesis to inform stakeholders involved in both writing and implementation and those supporting delivery of these policies at the national level.

Conclusion

To optimise antimicrobial use in human populations, flexibility is needed in the face of changing contexts and resources. The current inequities in funding, availability of resources, and investment in research capacity translate into unsustainable delivery. Therefore, facilitating operationalisation and delivery of AMR mitigation strategies in human populations requires developing NAP objectives that prioritise country-level needs and existing infrastructure. To support the work of key policy-decision makers existing gaps and opportunities need to be addressed to: (1) foster in-country development and translation of NAP policy and implementation through stakeholder engagement and political commitment, (2) identify deliverable NAP objectives that focus on optimising antibiotic use, (3) understand and invest in the human resource capacity needed in translating and operationalising NAP objectives, and (4) develop and measure indicators that are specific to AMR in human populations. These goals require long-term vision and investment in health systems resources, research, and infrastructure capacity.

Contributors

EC, RA, MMe, MMp, and AHH conceived the project and obtained funding. EC, CB, OM, VN, SJCP, and VA-V collected the data and had access to the raw data. EC and SJCP verified the data. EC, MMe, SJCP, OM, CB, and MMp analysed the data. EC and MMe wrote the first draft, all coauthors contributed to subsequent versions and approved the final draft. All authors had full access to all the data in the study and EC had the final responsibility for the decision to submit for publication.

Declaration of interests

EC has consulted for or received speaker fees from Pfizer and bioMérieux on educational material related to antibiotic resistance and antimicrobial stewardship. LSPM has consulted for or received speaker fees from bioMérieux, Pfizer, Eumedica, Kent Pharma, Umovis Lab, Shionogi, Pulmocide, Sumitovant, and received research grants from the National Institute for Health and Care Research (NIHR), CW+ (ie, the official charity of Chelsea and Westminster Hospital National Health Service Foundation Trust), Infectopharm, and LifeArc. All other authors declare no competing interests.

Data sharing

There was no data sharing plan set out at the beginning of this study. All data extracted from the NAPs were at national level and de-identified. The antibiotic consumption data used in the secondary analysis are de-identified and from publicly available sources. Specific requests for the de-identified data for valid academic reasons as judged by the first authors will be granted, with appropriate data sharing agreement, and should be sent to the chief investigator (EC).

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