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One Health WASH: an AMR-smart integrative approach to preventing and controlling infection in farming communities

Chris E Pinto Jimenez ,[1] Sarai M Keestra ,[1] Pranav Tandon ,[2] Amy J Pickering ,[3] Arshnee Moodley ,[4,5] Oliver Cumming ,[6] Clare I R Chandler [1]

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For numbered affiliations see end of article.

Correspondence to
Dr Chris E Pinto Jimenez; cpintoj@gmail.com

INTRODUCTION

Prevention is a critical, yet neglected, cornerstone for the response to antimicrobial resistance (AMR).[1] The importance of a multitude of preventative measures is recognised across the One Health spectrum, with attention drawn to the issue by multilateral institutions. The 2022 World Antimicrobial Awareness Week saw the World Health Organization, the Food and Agriculture Organization, the United Nations Environment Programme and the World Organisation for Animal Health focused their campaign on the theme 'Preventing AMR together' to improve awareness and understanding of AMR and encourage best practices.[2] While a One Health framework is now promoted for conceptualising the complex problem of AMR, the evidence base of interventions designed within this rubric is thin. Outstanding questions remain, for example, about how best to prevent and control infection across humans, animals, and the environment.

In public health, measures such as hygiene practices, biosecurity, vaccinations and other means to strengthen immunity, are commonly used to prevent and control infections. Highlighting the potential contribution of such measures to reducing AMR, the World Bank[3] introduced the terms 'AMR-sensitive' and 'AMR-specific' to describe interventions that indirectly or directly contribute to reducing AMR, respectively. For example, measures to reduce the burden of infections in human health, such as water, sanitation, and hygiene (WASH), are recognised as essential to support AMR strategies due to their potential to indirectly combat AMR and produce co-benefits.[3] Thus, investments in these interventions would be 'AMR-Smart.'

SUMMARY BOX

- ⇒ While the One Health framework is now widely accepted as a strength in understanding antimicrobial resistance (AMR), its application in intervention design to prevent and control drug-resistant infections across humans, animals, and the environment remains weak.
- ⇒ The potential for infection prevention and control measures to contribute to the AMR agenda is recognised in rhetoric, but evidence to guide action is patchy and uncoordinated.
- ⇒ While water, sanitation, and hygiene (WASH) and on-farm biosecurity interventions are key strategies for preventing and controlling infections, they are frequently implemented separately for humans and animals. We argue for integration across these sectors to improve planning for AMR control.

Currently, measures to prevent and control infections in human health are most obvious for infections acquired in healthcare settings. Infection Prevention and Control (IPC) in human health is considered fundamental for AMR, defined as measures '*that prevent patients and health workers from being harmed by avoidable infections and as a result of AMR*'.[4] In animal health, the prevention and control of infections commonly focus on measures to reduce the risk of introduction and/or spread of diseases between animals on farms and from and to farm workers. While the acronym IPC most commonly refers to healthcare settings in the human health sector, the general principle of infection prevention and control has a wider resonance. The subtle but important differences in the terminology for prevention and control of infections between health sectors have the potential to create misunderstandings across the wider One Health

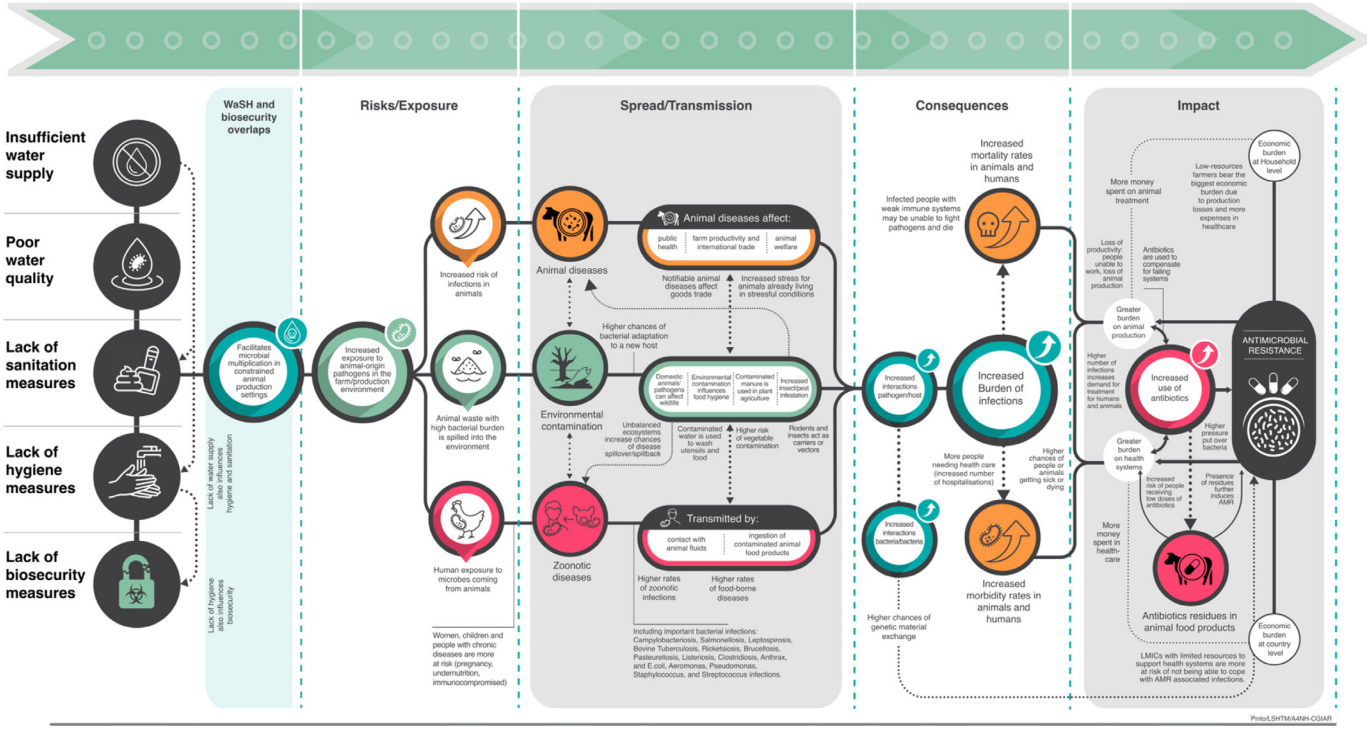

Figure 1 One Health framework to conceptualise how lack of WASH and biosecurity measures could contribute to the development of AMR. AMR, antimicrobial resistance; LMICs, low-and middle-income countries; WASH, water, sanitation and hygiene.

sphere, with consequences for the design and assumptions embedded in AMR interventions and programmes.

Measures to prevent and control infections at a community level in animal agricultural settings where humans and animals live in close contact is an overlooked area ripe for a One Health approach, especially when a significant proportion of the global population is involved in small-scale, semi-intensive livestock farming. It has been estimated that around 1 billion people (about 12% of the global human population) rely on smallholder livestock production[5] and about 60 million on aquaculture for their livelihoods.[6] The livestock population slaughtered for meat consumption in 2018 was estimated to be as high as 82 billion animals (69 billion chickens, 1.5 billion pigs, 656 million turkeys, 574 million sheep, 479 million goats and 302 million cattle).[7] These figures are especially significant for low-and middle-income countries (LMICs) where animal production systems contribute to nearly 40% of countries' agricultural gross domestic product and 2–33% of household incomes.[5]

In this commentary, we propose an integrative approach to infection prevention and control by combining WASH and biosecurity interventions to tackle AMR in human and animal populations beyond healthcare facilities, such as in settings where people and animals interact closely.

WASH AND ON-FARM BIOSECURITY AS INFECTION PREVENTION AND CONTROL MEASURES

WASH comprises a group of measures to provide or improve drinking water supply (water quantity), as well as to remove or inactivate pathogens and chemicals 'at source' and/or 'at point of use' (water quality), to provide or improve facilities for the disposal of human waste (sanitation), and to promote or implement changes in hygienic practices (hygiene).[8] A recent study[9] suggests biosecurity measures in animal health to be defined as '*the implementation of a segregation, hygiene or management procedure (excluding medically effective feed additives and preventive/curative treatment of animals) that specifically aims at reducing the probability of the introduction, establishment, survival or spread of any potential pathogen to, within or from a farm, a linked processing operation or a geographical area*'. Further breaking down the concept of biosecurity involves subdividing it into measures covering the areas of bioexclusion (the practices which together prevent the introduction of new pathogens), biocontainment (the escape of pathogens to neighbouring farms/animal facilities), and biomanagement (the control and management of pathogens already present in farms/animal facilities).[10] Both WASH and biosecurity measures overlap in many areas as both aim to reduce health risks and exposure to hazardous microorganisms in humans and animals, respectively. Yet, they are commonly implemented in different ways, with significant conceptual differences.

Despite WASH in healthcare settings starting to gain attention in recent years,[11] most WASH interventions are implemented in 'open' systems at a community level and focus on providing infrastructure for clean water and sanitation or changing hygiene practices by humans, primarily aiming to reduce enteric infections

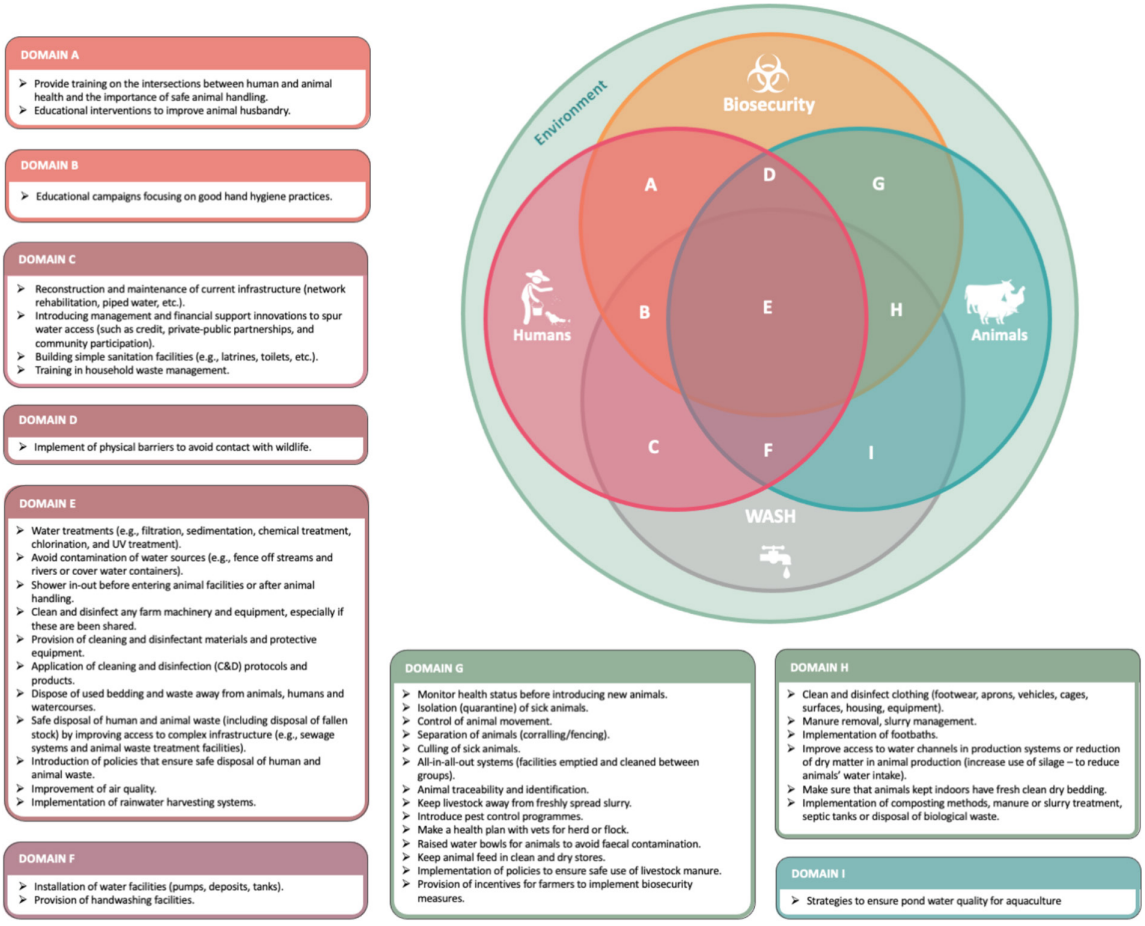

Figure 2 Examples of WASH and biosecurity interventions and their intersections. WASH, water, sanitation and hygiene. A list of traditional WASH and biosecurity measures is highlighted here to showcase their overlaps and interconnections. We identified different domains where both fields have intersections and organised the interventions accordingly. While many WASH and biosecurity interventions traditionally focus on either human and animal health, both can be implemented together in settings where humans and animals interact closely, such as in animal agricultural communities. As shown in the figure, most interventions are relevant for both, while few are relevant to only one health sector. The list of interventions included here is not exhaustive. Some interventions highlighted here should be implemented with support from local and national governments to ensure sustainability. Interventions should be selected according to the specific characteristics of the settings where the farming activity is taking place.

by preventing faecal-oral transmission of pathogens between humans and decreasing human exposure to human faeces. These interventions do not commonly recognise the added benefit of WASH to reduce exposure to pathogens coming from/to animals other than those associated with diarrhoea, despite being implemented in agricultural communities mainly composed of smallholders and subsistence farmers in close contact with animals. They often do not measure animals' negative or positive contributions to the outcomes of the implemented measures.

By contrast, biosecurity interventions frequently operate in 'closed' systems (at a farm level) and focus on avoiding or managing the introduction of various pathogens of significance to animal health and diverse transmission pathways. Compared with WASH, the concept of biosecurity takes a broader approach to improve the farm environment. For example, managing air quality—not just water quality or hygienic practices—is often considered crucial for reducing the risk of infections on farms. Although some on-farm biosecurity interventions account for the potential risk of introduction of infections for animals by farmworkers, this is frequently associated with known animal pathogens important for international trade, whereas the presence of opportunistic bacteria in humans that are not considered highly infectious but could carry antimicrobial resistance genes (ARGs) is not commonly assessed, despite evidence of transmissions such as methicillin-resistant *Staphylococcus aureus* between farmworkers and animals and vice versa.[12 13] While biosecurity interventions can effectively prevent and control infections in animal production systems, their ability to contribute to better health outside of farms has been less investigated. As well, there has been a disproportionate placement of responsibility to implement biosecurity measures on farmers, with little education and training for farm workers, no opportunities for knowledge co-creation with other stakeholders,

Table 1 Adapted definitions of WASH and biosecurity for implementing the integrative approach: One Health WASH in settings where humans and animals interact closely

WASH components	Interventions to address components across humans, animals, and the environment	Biosecurity components
Water	Water access: interventions to provide infrastructure or improve water distribution systems, or implement policies to ensure access to water for drinking or cleaning, safeguarding human and animal health and welfare. It may include strategies such as installing pumps, deposits, tanks, rainwater harvesting systems, or improving access to water channels in animal production systems.	Bioexclusion
	Water quality: Interventions to remove or inactivate pathogens 'at source' and 'at point of use' or the implementation of policies to ensure clean water for both humans and animals. These may include the application of treatments such as filtration, sedimentation, chemical treatment, chlorination, ultraviolet (UV) treatment of water, and interventions that improve drinking water through acidification or those that improve water quality in aquaculture.	
Air	Air quality: to prevent the dissemination of airborne pathogens between humans, animals and to/from humans. It may include implementing strategies to improve ventilation in the household and in animal dwellings.	Biomanagement
Sanitation	Sanitation infrastructure: to provide or implement infrastructure for the safe disposal of human waste to reduce access of animals or vectors to it. It may include interventions such as the installation of waste systems or the provision of sanitation facilities that consider the presence of animals in the surroundings.	Biocontainment
	Waste management: to establish strategies or policies to safely dispose of wastewater or fallen stock and/or treat animal or human faeces to be used as fertilisers, preventing the spread and dissemination of microbial threats to and from the environment. It may include interventions such as the installation of waste systems, composting methods, manure treatment, septic tanks, slurry treatment, rubbish management, disposal of biological waste, identification and isolation of animal defecation sites, construction of wetlands, or removal of fallen stock.	
Hygiene	Food safety: introducing hygiene strategies to safely manage and store food products including of animal origin and animal feed, avoiding food cross-contamination. It may include improving food storage conditions, sterilisation, pasteurisation, and good butchering practices.	Bioexclusion
	Cleaning and disinfection: interventions to promote hygienic practices, implement protocols or enforce policies to facilitate good hygiene in the household, among individuals, and around animal dwellings, avoiding the introduction and spread of pathogens among humans and animals and the environment. It may include strategies such as providing equipment to facilitate farmers/producers/animal owner's handwashing or showering in and out of animal facilities, use of disinfectants, cleaning of animal facilities, use of chemical products, use of high-pressure cleaners or sanitisers, educational interventions focusing on individual hygiene, or policies facilitating the implementation of such practices.	Biomanagement
Other biosecurity measures not contemplated in traditional WASH	Barrier implementation: to preserve boundaries, implement barriers or introduce policy strategies to limit exposure to microorganisms between animals,and humans and control potential vectors and fomites. It may include the installation of footbaths, corralling of animals, pest control, maintenance of pets and birds outside farming facilities, implementation of barriers to avoid contact with wildlife, farmworkers changing clothes, animal movement restrictions, restrictions of personnel entering animal facilities, quarantine, isolation protocols, implementation of vacancy periods of animal facilities, identification and containment of animal pooping spots, use of masks by people with respiratory infections, or use of protective equipment when handling animals or their fluids.	Biocontainment
	Health protection: to implement specialised strategies to boost immunity or manage infections in humans and animals or improve access to healthcare, ensuring wellness, welfare, and productivity for humans and animals. For humans, it could include improving access to vaccinations for children and deworming strategies in schools. For animals, it could consist of training farmers on safe animal handling, implementing McREBEL protocols or veterinary protocols to vaccinate or treat animals.	Biomanagement

WASH, water, sanitation and hygiene.

nor engagement from industry and government, leading to challenges with compliance.[14]

While the biological differences between humans and non-human animals mean that microorganisms can affect them differently, causing disease in humans but not in other animals and vice versa, the potential for acquiring and disseminating ARGs, supporting the perpetuation of AMR in both pathogenic and non-pathogenic bacteria is very high.[15] Furthermore, the lack of knowledge on the directionality of microbial spread between humans and animals and the potential for ARGs dissemination between animals and humans[16–20] highlights the importance of integrative approaches to AMR prevention and control, especially when most deaths associated with AMR in 2019 were linked to *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Streptococcus pneumoniae*, *Acinetobacter baumannii* and *Pseudomonas aeruginosa*,[21] which can be both pathogenic and opportunistic bacteria for both humans and animals.

BEYOND WASH AND ON-FARM BIOSECURITY TOWARDS AMR-SMART ONE HEALTH WASH

The potential for WASH interventions to support AMR control strategies in communities, healthcare facilities, and animal and plant production is recognised.[22] However, implementing this in animal agricultural communities is not straightforward. In current practice, WASH and on-farm biosecurity interventions are not interconnected and are implemented and assessed separately. However, both can be applied in integrated approaches to prevent and control infections and complement each other to reduce burden of infections and AMR in humans and animals in settings where humans and animals interact closely. Furthermore, both WASH and biosecurity interventions can positively contribute to preventing environmental contamination as some of these measures focus on the safe disposal of human and animal waste.

To illustrate the interconnections and the relevance of WASH and biosecurity measures to the AMR agenda,

we developed a One Health framework by reviewing relevant research literature guided by a grounded theory approach. Drafts of the graphic were shared and improved through an iterative process between our interdisciplinary team which included expertise from veterinary medicine, medical anthropology, microbiology, environmental engineering, WASH and One Health. We proposed several pathways to conceptualise how poor WASH and lack of biosecurity measures in animal agricultural settings could contribute to infection prevention and control at different levels of the One Health triad. As both WASH and biosecurity share the goal of reducing exposure of people or animals to infectious agents to preserve health, the absence of such measures increases the likelihood of interactions between microbes-host and microbe-microbe. The absence of WASH and biosecurity may therefore increase microbial multiplication and spread, contributing to the emergence and dissemination of ARGs between humans, animals, and the environment. In this scenario, the development of AMR not only has health consequences but also affects the economy of farmers and increases healthcare expenditure, which is especially important in LMICs (figure 1).

We also explored a range of WASH and biosecurity interventions commonly implemented in LMICs and animal production settings. Through content analysis, we identified commonalities, interconnections, and potential gaps (figure 2) and proposed new definitions and examples of interventions from these commonly separated fields (table 1). Although the new proposed definition of biosecurity measures[9] proposes to exclude some veterinary medical interventions, in the typology presented here, we still include interventions traditionally considered part of biosecurity measures that are available in the current literature.

CONCLUSIONS

While WASH and on-farm biosecurity traditionally operate in open and closed systems, respectively, their potential to jointly contribute to the prevention and control of infections and AMR in farming communities beyond their traditional operating frameworks is significant, especially in communities where humans and animals interact closely and where the boundaries between them are not necessarily defined by infrastructure. As previously suggested,[23 24] it is crucial to also address the animal and environmental components within a One Health approach to AMR, and also to ensure air quality for human health within WASH interventions, especially in view of the current COVID-19 pandemic, which exposed our vulnerability to airborne pathogens and the risks of close interactions between humans and animals.

We suggest several pathways to illustrate WASH and biosecurity overlaps and their potential to impact AMR directly or indirectly in the human-animal-environmental interface. We propose integrating these two fields for the prevention and control of infections and AMR, which will improve not only human but also animal and environmental health, leveraging the synergies and differences of these two traditionally separated fields, and recognising their potential to complement each other when addressing health issues in the One Health triad.

Author affiliations
[1]Global Health and Development Department, Faculty of Public Health and Policy, London School of Hygiene & Tropical Medicine, London, UK
[2]Global Health Office, McMaster University, Hamilton, Ontario, Canada
[3]Department of Civil and Environmental Engineering, University of California Berkeley, Berkeley, California, USA
[4]CGIAR AMR Hub, International Livestock Research Institute, Nairobi, Kenya
[5]Department of Veterinary and Animal Sciences, University of Copenhagen, Copenhagen, Denmark
[6]Department of Disease Control, Faculty of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, London, UK

Twitter Chris E Pinto Jimenez @ChrisPintoJ and Clare I R Chandler @AnthroAMR

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ORCID iDs
Chris E Pinto Jimenez http://orcid.org/0000-0002-2123-2762
Sarai M Keestra http://orcid.org/0000-0002-6368-0977
Pranav Tandon http://orcid.org/0000-0003-4363-5623
Amy J Pickering http://orcid.org/0000-0001-6193-2221
Arshnee Moodley http://orcid.org/0000-0002-6469-3948
Oliver Cumming http://orcid.org/0000-0002-5074-8709
Clare I R Chandler http://orcid.org/0000-0001-6499-7522

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