African Journal of Social Issues 7 (1): 2024
Available online at https://Ajosdemar.com;
https://www.ajol.info/index.php/ajosi

DOI: https://dx.doi.org/10.4314/ajosi.v7i1.48

CC BY
p-ISSN 2672 – 5142; e-ISSN 2734 – 3324
Original Research

RAISING AWARENESS ON ANTIMICROBIAL RESISTANCE: A CASE STUDY OF TOP-DOWN AND BOTTOM-UP ENGAGEMENTS WITH LIVESTOCK FARMERS' IN DORMAA DISTRICTS, GHANA

[1]KOKA Eric and [2]GADZEKPO Audrey

[1]Department of Sociology and Anthropology, University of Cape Coast, Cape Coast, Ghana
[2] School of Communication Studies, University of Ghana, Legon, Accra, Ghana

Email: [1]ekoka@ucc.edu.gh [2]audreygadzekpo@gmail.com

ABSTRACT

Ensuring the welfare, health, and overall state of animals produced for food is both a moral duty and an essential aspect of ensuring the safety of food products. The utilisation of antibiotics for the purpose of preserving animal health has been subject to examination most recently as a result of the increase in antibiotic resistance on a global scale. This is a major problem for animal and human health on a worldwide scale since it has increased illness outbreaks and the prevalence of germs that are resistant to antibiotics. The possibility of the transmission of germs impervious to antimicrobials from animals to the environment and food chain is a real concern. One approach to tackle this issue has involved implementing top-down public education campaigns with the goal of educating livestock farmers about antimicrobial use (AMU) and antimicrobial resistance (AMR). The primary aim of this study was to augment grasp of the unrestricted engagement deeds that most effectively capture information regarding the variables that drive rural livestock farmers to use antimicrobials and their degree of cognizance regarding antimicrobial resistance. We utilised a case study methodology to examine four different community engagement initiatives (focus group discussions, key informant interviews, public engagement workshops, and media discussion shows) that involved livestock farmers and animal health officials in the Dormaa districts of Ghana. The focus of these activities was on the topics of antimicrobial use and antimicrobial resistance. The study found that empowering farmers through dialogical public interactions, using both top-down and bottom-up techniques, enables them to effectively share knowledge about antimicrobial usage and resistance. This empowerment also allows farmers to engage in peer learning through their networks and the media. According to the findings of this study, it is advisable for livestock producers and animal health professionals to collaborate regularly in order to raise awareness through the media about the consequences of using and developing resistance to antimicrobials in livestock production, as well as its impact on humans and the environment.

Keywords: Antimicrobial Resistance, Antimicrobial Use, Livestock, Public and Media Engagement

INTRODUCTION

The rising global demand for animal products has necessitated a corresponding expansion of livestock production using intensive farming methods, in response to the rapid increase in the world's population. This extension is seen to be more pragmatic and cost-effective. In most developing nations, the chosen method to tackle this problem has been the production of rapidly maturing food animals, such as chickens. However, these intensive farming methods subject food animals to a significant number of antimicrobials administered by farmers for different reasons. This leads to the proliferation of bacteria that are resistant to drugs and reduces the effectiveness of conventional treatments used to treat bacterial infections in food animals. The utilisation of identical antibiotics in both veterinary and human medicine raises considerable concerns about the impact of antimicrobial usage (AMU) on individuals through the food chain (Caudell, Dorado-Garcia, Eckford, Creese, Byarugaba, Afakye, Chansa-Kabali, Fasina, Kabali, Kiambi, Kimani, Mainda, Mangesho, Chimpangu, Dube, Kikimoto, Koka, Mugara, Rubegwa, & Swiswa, 2020). The process by which microorganisms (such as bacteria, viruses, fungi, and parasites) adapt or change to withstand the medications meant to kill them is known as antimicrobial resistance, or AMR.

While AMR is an innately occurring phenomenon, its global prevalence is rising due to the excessive use, misuse, and poor disposal of antibiotics. Due to its impact on individuals, animals, and the ecosystem, and the need for collaboration across several fields to tackle it, it is seen as a One Health concern (Mitchell, Cooke, Ahorlu, Arjyal, Baral, Carter, Dasgupta, Fieroze, Fonseca-Braga, Huque, Lewycka, Kalpana, Saxena, Tomley, Tsekleves, Vu Thi Quynh, & King, 2022).). If no action is taken within the next ten years, Antimicrobial Resistance (AMR) could have a similar economic impact as the 2008 financial crisis. This could lead to 300 million deaths and 28.3 million people living in poverty by 2050. The majority of those affected (26.2 million) will be in low- to middle-income countries (LMICs) (Seale, Gordon, Islam, Peacock, & Scott, 2017). These nations face substantial discrepancies in healthcare, economic inequities, and governmental corruption (Khan, Durrance-Bagale, Legido-Quigley, Mateus, Hasan, Spencer, & Hanefeld, 2019). As a consequence, there is a lack of satisfactory financial gains from taxation and insufficient cleanliness and sanitation systems, rendering them more susceptible to elevated mortality rates caused by antimicrobial resistance (AMR) (Deo & Anjankar, 2023). Multiple research teams are actively engaged in combating antimicrobial resistance (AMR) through the development of novel drugs and the implementation of top-down changes in antimicrobial usage policy. AMR represents a significant threat to food security, global health, and economic stability (Hoffman, Caleo, Daulaire, Elbe, Matsoso, Mossialos, Rizvi, & Røttingen, 2015; Van Katwyk, Balasegaram, Boriello, Farrar, Giubilini, Harrison, Kieny, Kirchhelle, Liu, Outterson, Pate, Poirier, Røttingen, Savulescu, Sugden, Thamlikitkul, Weldon, Davies, & Hoffman, 2019).

In underdeveloped countries such as Ghana, livestock and poultry have a substantial impact on both the food supply and the overall economy. However, they may also pose a risk to human health as they provide a refuge for human diseases, which can transfer antibiotic resistance genes amongst bacteria. Hence, the inappropriate use of antibiotics by farmers or veterinarians can worsen the prevalence of antibiotic-resistant microorganisms (AMR) in all living things during the treatment of illnesses. Antimicrobial resistance (AMR) has become a major public health subject in underdeveloped countries with a high prevalence of infectious

diseases in animals and a heavy reliance on antimicrobial drugs for both medical treatment and non-medical uses. Hence, to mitigate the risk of antimicrobial resistance, it is imperative to address the reliance on antibiotic consumption.

PROBLEM STATEMENT/RATIONALE OF THE STUDY

Ghana is classified as a lower middle-income country, with its economy predominantly reliant on agriculture. Consequently, the livestock industry is highly preoccupied with ensuring food security, safety, and quality. Studies have shown that reducing the use of antimicrobials by veterinarians can decrease the risk of antimicrobial resistance (AMR) caused by animals by helping to reduce the main cause of AMR. Minimising the dosage of veterinary antibiotics would not only safeguard animal health but also ensure consistent animal productivity. The full comprehension of the severity of the AMR epidemic in Ghana's livestock industry is hindered by a dearth of information regarding the utilisation of veterinary antibiotics in instances of outbreaks among livestock in general, and specifically in poultry and cattle. Hence, it is imperative to understand the perspectives and expertise of farmers concerning antimicrobial resistance (AMR) to pinpoint the factors that could contribute to the excessive or improper use of antibiotics in their agricultural methods, especially during instances of disease outbreaks (O'Mara-Eves, Brunton, Oliver, Kavanagh, Jamal, & Thomas, 2015).

In five African countries (including Ghana), a multi-country study on the bottom-up understanding of antimicrobial use and resistance on farms discovered that people who lived or worked on farms relied on their knowledge and experiences, frequently with advice from neighbours, family, and friends, when making decisions about the healthcare of their animals (O'Mara-Eves et al., 2015). Furthermore, the study discovered that these networks were in charge of giving antimicrobials to animals, mostly for medicinal reasons but also, more frequently, to help with animal growth and illness prevention for pastoralists. The survey's findings indicated that a significant proportion of participants primarily relied on local pharmacies to purchase antimicrobial drugs without a prescription. Moreover, the study revealed that respondents seldom sought advice or treatment from animal health specialists in relation to antibiotics.

These results point to a lack of awareness and comprehension regarding the usage of antibiotics by livestock farmers in nations like Ghana. The research on Community Engagement's (CE) competence to lecture health issues in low- and middle-income countries (LMICs) is expanding but little advice on smearing CE methods, specifically, to AMR (Allotey & Harel, 2019; Charoenboon, Haenssgen, Warapikuptanun, Xayavong, & Khine Zaw, 2019; Haenssgen, Charoenboon, Thavethanutthanawin, & Wibunjak, 2021; Thornber, Huso, Rahman, Biswas, Rahman, Brum, & Tyler, 2019). The reason for this may be because AMR has traditionally been seen as a biotic issue that necessitates top-down remedies, such as policy and system-level modifications, rather than bottom-up initiatives that involve community involvement strategies and the exchange of information among stakeholders through dialogue (Khan et al., 2019). Employing a hierarchical method in engaging the community for combating antimicrobial resistance (AMR) in cattle has numerous advantages (Rifkin, 2014). Farmers typically see veterinarians as reliable, establishing them as the main authority on the judicious application of antimicrobials. They frequently depend on reputable veterinary societies, scholarly journals, and peer conferences for trustworthy information. These sources

have the potential to be effective channels for reaching veterinarians using a top-down approach in continuing education (Kinnison, May, & Guile, 2015).

The professional veterinary associations use the top-down method to communicate coherent, consistent, and unambiguous messages while working with governments and other significant stakeholders. Additionally, through these channels of information, best practices for reducing the use of antibiotics in a sustainable manner are better shared, educating farmers and veterinarians and inspiring them to adopt these methods (Kinnison et al., 2015; Rifkin, 2014). To withstand (perceived) pressure from farmers, professional standards and guidelines through top-down approach in CE have their value in harmonising the prescribed behavior changes between farmers and veterinarians (Rifkin, 2014). Still, the responsible use of antibiotics in livestock necessitates the adoption of many management and treatment strategies, which call for alterations in human behaviour. According to certain literature, bottom-up methods can investigate the local antimicrobial usage context, which can help with the joint development of customised solutions to reduce AMR in that community. The advantages of this kind of community engagement (CE) are especially significant for LMICs, since this strategy's local distinctiveness allows it to account for a great deal of the intricate disparities associated with AMR (Allotey & Harel, 2019).

This paper discusses this potential based on an exploratory study that looked at four different community involvement interventions on antimicrobial use in Ghana's Dormaa and Wamfie districts, engaging livestock farmers and animal health professionals. Our goal was to shed light on the best ways to inform and educate farmers on the appropriate use of antimicrobials at the farm level through the combination of top-down and bottom-up dialogical approaches. We contend that such an approach will aid in the creation and execution of behavioural change interventions to address antimicrobial resistance, particularly in light of the limited input offered by animal health professionals and the regulatory capabilities that are unsatisfactorily funded within a nation like Ghana.

LITERATURE REVIEW

Antimicrobial resistance (AMR) arises when microorganisms develop resistance to medications employed in the treatment of illnesses. While antimicrobials, including antibiotics, play a vital role in safeguarding animal health in livestock systems, their improper use or excessive usage contributes in the wake of, dissemination, and endurance of antimicrobial resistance (AMR) (Caudell et al., 2020; Davies, 1996; Landers, Cohen, Wittum, & Larson, 2012). Antimicrobial resistance (AMR) is increasing, leading to longer treatment durations and failures in therapy. Worldwide, this is a major threat to people's well-being, the safety of our food supply, and the treatment of animals. Resistant microorganisms, including bacteria, viruses, and parasites, have the ability to transmit between humans and animals via pathways such as the depletion of animal products, direct physical acquaintance, and shared water supplies. This can lead to a higher incidence of contagious illnesses in the human population (Levy & Bonnie, 2004). The risk of extensive transmission and treatment failures is substantial, principally cogitating that nine out of the fourteen medicine categories classified as "critically important" for public health are also utilised in livestock operations. Anticipated is a 67% surge in the utilisation of antimicrobials in agriculture by 2030, thereby exacerbating the vulnerability of medications for both animal and human health (Van Boeckel, Pires, Silvester,

Zhao, Song, Criscuolo, Gilbert, Bonhoeffer, & Laxminarayan, 2019). Given the connection underlying agricultural antibiotic use and public health, antimicrobial resistance (AMR) has emerged as the most pressing contemporary manifestation of the One Health paradigm obliging alliance past masteries, subdivisions (public and private) and scales as locally-bottom-up, universally) to more effectively oversee AMR in people, animals, and the environment (Robinson, Bu, Carrique-Mas, Fèvre, Gilbert, Grace, Hay, Jiwakanon, Kakkar, Kariuki, Laxminarayan, Lubroth, Magnusson, Ngoc, Van Boeckel, & Woolhouse, 2016; Zinsstag, Schelling, Waltner-Toews, & Tanner, 2011).

The prevalence of infectious diseases and frequent human-cattle interactions, determined by livelihoods and living situations, have a substantial impact on low- and middle-income countries (LMICs) in terms of antimicrobial resistance (AMR). Studies conducted in these geographical areas demonstrate that antimicrobial resistance (AMR) has the potential to disseminate among human populations, animal populations, and the surrounding ecosystem. Similar genotypes of resistant enteric bacteria have been detected in humans, animals, and water sources in Tanzania (Guenther, Ewers, & Wieler, 2011; Katakweba, Møller, Muumba, Muhairwa, Damborg, Rosenkrantz, Minga, Mtambo, & Olsen, 2015). Salmonella infections in Ugandan humans and animals followed comparable trends (Afema, Byarugaba, Shah, Atukwase, Nambi, & Sischo, 2016). Conversely, genotypic investigations conducted in affluent nations typically reveal separate antimicrobial resistance (AMR) outbreaks in cattle and the overall population (Day, Hopkins, Wareham, Toleman, Elviss, Randall, Teale, Cleary, Wiuff, Doumith, Ellington, Woodford, & Livermore, 2019; Mather, Reid, Maskell, Parkhill, Fookes, Harris, Brown, Coia, Mulvey, Gilmour, Petrovska, De Pinna, Kuroda, Akiba, Izumiya, Connor, Suchard, Lemey, Mellor, & Thomson, 2013). These patterns correspond to a situation where there is minimal interaction between the general people and cattle, and where there are established systems in place for health, sanitation, and regulations that minimise the occurrence of disease transmission (Collignon, Beggs, Walsh, Gandra, & Laxminarayan, 2018; Hendriksen, Munk, Njage, van Bunnik, McNally, Lukjancenko, Röder, Nieuwenhuijse, Pedersen, Kjeldgaard, Kaas, Clausen, Vogt, Leekitcharoenphon, van de Schans, Zuidema, de Roda, Rasmussen, Petersen, Aarestrup, 2019; Mather et al., 2013).

A study conducted in the Netherlands observed a parallel between antimicrobial resistance (AMR) in livestock, specifically pigs, and humans. The study found that there was a larger degree of overlap in farming areas where there was greater intensity of contact between animals and people (Gundran, Cardenio, Salvador, Sison, Benigno, Kreausukon, Pichpol, & Punyapornwithaya, 2020). These studies suggest that efforts to manage antimicrobial resistance (AMR) should be personalized to the unique characteristics and statuses of each individual place and community. Consequently, it is critical to carry out research that looks at the specific factors that lead to antimicrobial resistance (AMR) and the inappropriate use of antibiotics at the local, state, and federal levels. Low- and middle-income countries' (LMICs) limited regulatory capabilities and insufficient funding for veterinary healthcare systems make it difficult to embolden the conscientious use of antibiotics and raise public awareness of the management of antimicrobial resistance (AMR) in the agriculture sector (Bebell & Muiru, 2014; Okeke, Laxminarayan, Bhutta, Duse, Jenkins, O'Brien, Pablos-Mendez, & Klugman, 2005).

In Ghana, the Food and Agriculture Organisation of the United Nations, the veterinary

department, and the Ministry of Food and Agriculture are collaborating to encourage the responsible use of antimicrobials. The implementation of multisectoral National Action Plans is becoming more prevalent in guiding these endeavours. These plans receive support from the Tripartite Collaboration on AMR, which comprises the Food and Agriculture Organisation (FAO), the World Organisation for Animal Health (OIE), and the World Health Organisation (WHO). National Action Plans establish a set of objectives to enhance understanding of antimicrobial resistance (AMR) and associated risks, build the ability to track and monitor the use of antimicrobials and AMR, reinforce governance, and encourage responsible use of antimicrobials in the public and animal health domains (Lele & Goswami, 2021; Van Katwyk, Wilson, Weldon, Hoffman, & Poirier, 2022). The regulatory bodies with limited resources, such as food safety agencies and national medical authority, further impede the implementation of National Action Plans. This makes it difficult to enforce national rules, such as legislation requiring antibiotic prescriptions or regulations on antimicrobial residues, and the incapacity to standardize lees can have a major effect on commerce (Okeke et al., 2005).

The enactment and prosecution of National Action Plans in low- and middle-income countries (LMICs) through a top-down strategy offers the advantage of efficiency and broad coverage, as long as adequate resources are committed. However, utilising 'bottom-up' approaches to alter behaviour, which entail involving stakeholders from the beginning of the process, typically lead to longer-lasting change. Therefore, it is projected that nations will reap the most value from an integrated approach. These initiatives, which will begin at the grassroots level, will be contingent upon a consciousness of the sociocultural, economic, and historical elements that effect the use of antimicrobials and related practices (such as adhering to withdrawal periods) in livestock systems. Unfortunately, there is currently a lack of evidence addressing the behaviours of antimicrobial use and the factors that influence such practices in livestock systems in most low- and middle-income countries (LMICs) (Founou, Founou, & Essack, 2016; Omulo, Thumbi, Lockwood, Verani, Bigogo, Masyongo, & Call, 2017; Van Katwyk et al., 2022).

Studies indicate that farmers typically self-administer antimicrobials without prescriptions or guidance from animal health professionals. Also, they frequently act irresponsibly, including not taking antibiotic withdrawal periods into account. These are the times leading up to slaughter when the animal must stop receiving these medicines so they can be completely removed from their system (Auta, Hadi, Oga, Adewuyi, Abdu-Aguye, Adeloye, Strickland-Hodge, & Morgan, 2019; Caudell et al., 2017). Compound research groups are working to find solutions to antimicrobial resistance (AMR), which poses grave dangers to human health, food security, and the economies of other nations. One approach is to develop new medications, while another is to reform antimicrobial policies from the top down (Van Katwyk et al., 2022).

Nevertheless, AMR is a societal problem influenced by human conduct. Therefore, our study aimed to address it by actively involving communities in promoting the responsible use of antimicrobials through a grassroots approach. Bottom-up methodologies can investigate the specific circumstances of antimicrobial use in a certain area, which can then help in developing customised solutions to reduce antibiotic resistance in communities. The advantages of community engagement (CE) are especially significant when addressing low- and middle-income countries (LMICs), as this method can address many of the intricate inequities

connected to antimicrobial resistance (AMR) by considering the local context (O'Mara-Eves et al., 2015).

The relevance of public engagement and media education on antimicrobial resistance in livestock farming

Community Engagement can be defiant contemplating the dynamic nature of AMR and the difficulties involved in implementing social and behavioral change campaigns, especially when such behaviors are routine behaviors (Mitchell et al., 2022). Within numerous studies, the research team may have an incomplete understanding of the underlying factors that generate resistance among local drivers. Additionally, the material provided to the community may undergo modifications throughout the course of the project. This has the capacity to generate distrust between the community and academics and may also clash with established frameworks for community engagement. When examining the Ladder of Participation by Arnstein in the context of AMR, it is possible that the community does not have complete or delegated authority over the process due to the fluctuating local AMR information they get (Mitchell et al., 2022). During a CE for AMR intervention, there will be periods where information needs to be communicated to the community in a one-way manner. Additionally, the research team must address and rectify any misinformation circulating at the community level. Engaging in this activity is crucial for addressing AMR in a specific community, but it may hinder the community's ability to learn independently, a challenge that is acknowledged in various health-related uses of CE (Adhikari, Pell, & Cheah, 2020).

AMR continues to be a One Health issue, meaning that when conducting AMR research, teams must take into account behaviours that go beyond human health, such as agricultural, veterinary, and environmental activities. There is a shortage of frameworks to support such interdisciplinary collaboration. Therefore, it is necessary to have effective public and media interactions in order to educate communities and dispel any misconceptions and uncertainties that may come from the unique perspectives of community members. Ultimately, there is a lack of agreement on whether CE can effectively tackle AMR. Assessments often concentrate on alterations in knowledge, attitudes, and behaviour, and multiple research projects indicate that merely increasing awareness of antimicrobial resistance (AMR) is insufficient to induce a shift in practice or conduct (Charoenboon et al., 2019; Haenssgen, Xayavong, Charoenboon, Warapikuptanun, & Zaw, 2018; Jimah, Fenny, & Ogunseitan, 2020).

In and of itself, evaluating behavioural modifications is difficult, and many studies rely on self-identified information, which casts doubt on their veracity in the eyes of certain academic fields and legislators (Rifkin, 2014). Given the intricate nature of the subject, researchers who are using CE for AMR and One Health challenges need further direction and active participation from the community. This article discusses the importance of incorporating both bottom-up and top-down approaches in public and media engagements to effectively address AMR among livestock farmers. These interventions should be characterised by open dialogue, informative content, engaging methods, and strong evidence.

METHODOLOGICAL CONSIDERATIONS

The study utilised a descriptive case study approach, which involved gathering qualitative data through Focus Group Discussions and In-depth interviews with specific farmers and key informants in the study communities. Additionally, public and media engagement interventions were conducted, which included workshops and radio discussion programs featuring livestock farmers and animal health officials. The research was conducted in two district capitals, specifically Dormaa Central-Dormaa Ahenkro and Dormaa East-Wamfie, located in the Ahafo Region of Ghana.Both districts are sited in the semi-equatorial region, characterised by a bi-modal rainfall pattern. Both locations are situated within the latitudes of 70 degrees North and 70 degrees 80 minutes North, and the longitudes of 20 degrees 35 minutes West and 30 degrees 30 minutes West. Approximately 68.4% of households in the two districts are involved in agricultural activities, primarily focused on poultry and livestock farming. These districts have the highest chicken production in the country, with over 3.1 million layers and 1 million broilers. This influenced the selection of the study areas for the research. In addition to poultry, community members are also engaged in the breeding of cattle and pigs. Based on this information, we decided to incorporate cattle farmers and individuals involved in the value chain into our interventions. In order to facilitate a meaningful flow of information on antimicrobial resistance (AMR) between animal health professionals and farmers, six government veterinary staff members were included. This group consisted of one District Veterinary Officer (DVO) and five Veterinary Technical Officers (VTOs). The study participants were deliberately chosen for both the focus group discussions (FGDs) and the key informant interviews (KII) based on their possession of the necessary information for the study.

Selected key informants in the Dormaa and Wamfie districts were interviewed extensively to gather information on their awareness, knowledge, and practices about outbreaks, antimicrobial usage, antimicrobial resistance, and farmers' management techniques. A total of five (5) key informant interviews were carried out with veterinary personnel, including three (3) staff members from Dormaa and two (2) staff members from Wamfie, in the respective districts. We held two focus group discussions (FGDs) to help the communities come up with participatory opinion methods of construction. These FGDs involved 12 participants each and were specifically organised for poultry and cattle farmers in the two districts. One focus group discussion (FGD) should be conducted for each community. The replies and findings obtained from these two primary data collection methodologies played an imperative character in shaping the design of the educational materials and media campaigns used for community engagements in these districts.

A public education workshop was organised for poultry and cattle farmers in the Dormaa and Wamfie districts. The two main approaches used were bottom-up and top-down strategies in engaging with the farmers and other stakeholders like the butchers as follows:

In the initial approach (bottom-up), farmers exchanged their experiences and expertise regarding their management techniques in relation to the usage of antibiotics. These were their subjective viewpoints on management practices and the utilisation of antibiotics. Several crucial concerns were highlighted regarding their management procedures and the rationale behind their utilisation or non-utilization of antibiotics on their farms. Furthermore, a radio conversation took place with the leaders of the cattle farmers' association, poultry farmers' association, and butchers' organisation. The discussions also focused on the consequences of

employing antimicrobials on farms for both animal and human health, strategies to improve and maintain effective management practices, and the influence of COVID-19 regulations on farming operations. Given that community members were leading the talks on radio, this intervention might be considered as a manifestation of the bottom-up method in community engagement for antimicrobial use/antimicrobial resistance.

The second approach, which was a top-down one, was a public engagement which was facilitated by officials from the Veterinary Services Department and social scientists. This was where facilitators educated farmers on antimicrobial use and resistance, and their implications on animals, environment and human beings, and on zoonotic diseases and their implications on public health**.** In all, 30 participants took part in the public engagement. These featured all 24 farmers raising cattle and poultry who participated in the previous focus groups held in each of the two districts (12 in each area). The rest were 6 stakeholders (agro vets, egg sellers and butchers) from the two districts. By convening these essential stakeholders, we facilitated meaningful discussions and provided valuable education. This allowed for the exchange of crucial information and the explanation of significant issues related to zoonotic diseases, antibiotic usage and resistance, biosecurity, good management practices, and disease outbreaks and their control. The public engagement sessions yielded valuable insights, revealing that both bottom-up and top-down approaches fostered peer education and information sharing among participants, particularly farmers who had limited knowledge about AMU/AMR and its consequences. Nevertheless, it is crucial to acknowledge that the limited availability of resources restricted the possibilities for further public involvement. Therefore, it became necessary to implement the approach of utilising the media for additional engagement, a concept that arose over the course of conversations.

Subsequent to the public engagement workshop, three radio panel discussions were conducted on two local FM stations (Dormaa FM and Voice FM) in the Dormaa area on March 28, April 1, and April 5, 2020. The panels of the workshop were composed of stakeholders, including a chief butcher, a veterinary doctor, the chairman of the poultry farmer's association, and an official from the Ministry of Health. The workshop was hosted by a media presenter. The radio conversations focused on the utilisation and resistance of antimicrobial agents, effective management techniques, and understanding of antimicrobial resistance. In early March, the first cases of COVID-19 were detected in Ghana. This occurred a few weeks before the radio shows, which provided an opportunity to enhance understanding of zoonotic diseases and their impact on human health. The shows also facilitated discussions on how farming practices and involvement in the production value chain could make farmers and stakeholders more susceptible to COVID-19 infection.

Ethical considerations

The Noguchi Memorial Institute for Medical Research's Institutional Review Board at the University of Ghana gave its ethical stamp of approval to the study. Anyone who wanted to take part did so voluntarily, and they all gave written consent after being fully told. The participants' identities were not recorded verbatim in order to preserve their confidentiality. They were also not given official recognition. The data was only viewed by the research team for the sole tenacity of keeping it confidential; no other purposes were ever pursued.

FINDINGS

Referral of sick animals to the Veterinary officers

Findings from the study suggest that many farmers are confronted with all kinds of diseases on their farms and while some rely on veterinary staff for diagnosis and treatment, others do not. The following representative narrative supports underscores the point:

> *A farmer kept reporting of his animals growing lean and you end up selling the animal and when it is split or dressed, they see the lungs and some internal organs destroyed. He's been reporting it to me until once I told him when it happens and he's going to sell the animals whoever he sells it to he should let me know or if by chance it dies, he should call us to come and do some post-mortem so he sold one and he told me he has sold an animal to one of the butchers and he gave my contact to the butcher. I went there and he [the butcher] slaughtered the animal and dressed it and I realized it was that condition I suspected so we made a follow-up with some sample and it was proven positive … the CBPP contagious Bhutan pneumonia. So since then, I advised him that we should always do vaccinations for the cattle and so for the past three years the farmer calls to remind me that I have to do the vaccinations for the cattle including other farmers and now I do the vaccination regularly for all cattle in this area*

(KII, 47 -year-old Male Vet, Wamfie, 2020).

The above quote revealed that some vet officers have a very productive ongoing relationship with the farmers in diagnosing diseases in their livestock.

In proportion to the multi-country study piloted by O'Mara-Eves et al. (2015), our findings indicate that farmer workers primarily depend on their own knowledge and experiences, as well as those of their social networks (such as family, neighbours, and friends), when it comes to animal healthcare and decision-making. This includes the specific task of administering antimicrobial interventions. A cattle and poultry farmer explained it as follows:

> *Most of the time when my cattle or birds are sick, I prefer to consult my friends who are experienced in farming first for diagnosis and even prescription of some drugs'* (FGD, 51-year-old Male Cattle and poultry farmer, Dormaa, 2020).

The focus groups showed that farmers trust and value the work of animal health workers, even though they don't always trust their advice and treatments when it comes to antibiotics. A farmer had this to say:

> *We invite the veterinary officer here to come and see and advise us. So whatever the officer tells us to do, that is what we do. The officer here is very effective* **(**FGD, 45-year-old female poultry farmer, Wamfie, 2020).

In order to get antimicrobial merchandise, the majority of respondents stated that they leaned on local agrovet pharmacy shops, often sans prescriptions. A participant had this to say with regards to how drugs are administered to the sick cattle:

> *How to administer it is written on the drug label. So, I follow the instruction with the help of my son and we give the antibiotics to the cow or the cattle* (FGD, 55-year –old Male cattle farmer, Dormaa, 2020).

The monitoring of withdrawal periods following antimicrobial treatment was constrained due to farmers overriding and peddling animal yields (such as meat, milk, and eggs) from livestock that were either presently receiving treatment or still inside the withdrawal interval. A respondent's representative narrative confirmed this observation thus:

> *...I do not see anything wrong with selling my eggs after giving them antibiotics because the egg or meat will be boiled or fried…. So, the drug will not be active in the meat or egg after they are cooked…Again, we are talking about money here…. I will lose if I have to throw my eggs away because I give them antibiotics few days before selling them…* (FGD, 37-year-old female poultry farmer, Wamfie, 2020).

Antimicrobial use and antimicrobial resistance

Narratives from both the FGDs and KII showed that most farmers give out antibiotics indiscriminately to their cattle when they suspect sickness without consulting the vet. Participants shared the following experiences on how they administered antibiotics to their animals without prescription:

> *For that it's a lot; we do give animals antibiotics. We always give them first and if they are not getting better, then we invite the vet to come and examine them* (FGD,46-year-old male cattle farmer, Wamfie, 2020).
>
> *For me I do that a lot and sometimes it works sometimes too the antibiotics do not work. But I still give them whenever I suspect they are sick* (FGD, 45-year-old poultry farmer, Dormaa, 2020).

Qualitative responses from farmers suggest that the decision-making practices of selling animal products with antimicrobial residue without recourse to advise from vets exist among some of the farmers. Asked whether cattle are sold when they are on antibiotics, this was what some participants had to say:

> *If I realize the animal is not recovering and I fear I will lose it, I sell it or send it to butchers to slaughter and sell. After all, they are going to cook the meat and once the meat is cooked, it will not affect human beings* (FGD, 50-year-old cattle farmer, Dormaa, 2020).

Even though some farmers know the implications of giving out antibiotics without prescription, they still continue to engage in such risky behaviour because they perceive they have no options. However, others who are aware of the consequences of unprescribed antibiotic use and the risk of AMR take a more cautious approach:

> *…As for me I don't sell or kill my cattle when they are on antibiotics because it has a lot of effect on both the human being and the animal sometimes maybe as we are sitting here the person brought the animal to the slaughterhouse or sometimes you go to know that it is from somebody's house so sometimes we also do make inspections on the site of the injections to get to know whether 3 weeks ago there*

> *was some treatment before the animals was killed and so if you look at the animal you are able to know that the drug was not given well so the meat has deviated from the normal colour. So, you ask the butcher and condemn that part because should in case it didn't come to the slaughterhouse and it is a different place when somebody consumes it the person is going to have the antimicrobial resistance* **(**FGD, 44-year-old cattle farmer, Wamfie, 2020).

Another participant, in reacting to probes as to whether antimicrobial resistance could affect human beings if they consume the meat, had this response:

> *Yes, it can affect humans. The medicines that we give to the animals get into the system and come to humans when we eat them* **(**FGD, 40-year-old poultry farmer, Wamfie, 2020).

Yet another participant said:

> *Some of the drugs have the same components that humans use, so when we take our medicines, it doesn't work because one way or the other the animals have transferred it to us (*FGD,46-year-old male cattle farmer, Wamfie, 2020).

Overall, our findings indicate that farmers frequently recognised the connections connecting bio safety, disease, and antimicrobial usage. However, financial constraints hindered their ability to prioritise investments in epidemiological measures. As a poultry farmer for example, explained:

> *… Footbaths are something we should have but are missing. Feed and medication take up much of the budget, leaving little for frivolous expenses like footbaths and disinfectants* (FGD, 46-year-old female poultry farmer, Dormaa, 2020).

Farmers frequently reported facing obstacles when trying to reach animal health practitioners. A poultry farmer explained:

> *The medical officer will show up, but he won't have any tools with him, so he'll have to guess* (FGD, 48-year-old male cattle farmer, Dormaa, 2020).

Qualitative interviews with animal health professionals were consistent with farmer's perspectives indicating they had limited access to health services. A shortage of funding prevented health care providers from providing adequate services and holding necessary trainings, which was their primary grievance. A qualitative response from one of the health professionals buttressed this assertion thus:

> *We don't have the lab and the necessary equipment we will use for proper diagnosis and so most of the time we do guess work which is unethical to our profession* (KII, 52-year-old male vet, Dormaa, 2020).

Animal health professionals generally acknowledged inadequate biosecurity precautions as the main factor contributing to the usage of antimicrobial agents, which is in line with the conclusions drawn from interviews with farmers. Our qualitative interviews with agro vet staff provided evidence to corroborate this assumption, since they revealed that farmers frequently turned to them as one of their primary sources for health advice. Conversations with

agricultural veterinarians revealed that the majority possessed knowledge of antimicrobial resistance (AMR) and acknowledged the significance of obtaining medicine prescriptions from farmers. While recognising the significance of the issue, the majority of agricultural veterinary dealers admitted to selling antibiotics without requiring prescriptions. They make medicine judgements based on descriptions of symptoms or particular requests from farmers. These abuses persist due to the scarcity of government regulatory authorities tasked with enforcing these rules.

> *"I have been keeping this shop for 15 years", said one agro vet, "and I have been visited by [the agency], two times to ask about my drugs*" (KII, 56-year-old agro vet dealer, Dormaa, 2020).

DISCUSSION

Peer Learning: Experience Approaches

Participants in the public engagement were instructed on the topic of antimicrobial use and resistance (AMU/AMR) and thereafter empowered to communicate their experiences with other farmers. They showcased their skills and shared their experiences by engaging in a panel radio conversation on AMU/AMR and COVID-19 within respective communities. Prior to the program, the representatives from each stakeholder group, namely farmers, butchers, and veterinarians, informed their colleagues about the upcoming event. They encouraged them to tune in and, if permitted, participate in the call-in parts.

The radio debate demonstrated that the representatives of the groups who participated in the public engagement workshop had acquired further understanding of antibiotic use and resistance in cattle and were able to effectively convey that knowledge. This was apparent in the manner in which the farmer and butcher actively captivated their audience during the radio discourse. The discussion focused on management methods, specifically the improper use of antimicrobials, which contributes to the progress of antimicrobial resistance. Additionally, the conversation addressed the need to modify behaviour, such as discontinuing the indiscriminate use of medications in livestock. This radio presentation offered valuable information on the elements that contribute to the utilisation of antimicrobials in poultry and cattle farming in some regions of Ghana.

Listeners who identified as farmers confirmed the claims made during the show that although their understanding of antimicrobials and their impact on public health and biosecurity was reasonably sufficient, their adherence to proper antimicrobial use practices was inadequate. The discussions emphasised the importance of creating guidelines, protocols, and policies for farms, as well as implementing educational training programs and fostering sustainable community engagement. These actions are very central for helping farmers make smart choices about drug resistance and how to take care of antibiotics for animals. All panelists agreed that making farm-specific wellness programs mandatory, which were made with the help of vets, would efficiently improve sanitation and husbandry standards on their own farms. This is reflected in the narrative by one of the panelists thus: *One of the ways to ensure that biosecurity is practiced is to design guidelines and schemes that will be followed by all farmers in our community* (Radio discussion, 53-year-old panelist-Poultry Farmer, Dormaa, 2020).

The program's dialogical approach facilitated farmers in offering suggestions and

feedback to heighten the working relationship between farmers' organisations and animal health officials and academics. They also said they would be willing to work together on field-based or versatile study that could contribute to increasing the productivity and sustainability of chickens and cattle. The farmers emphasised the necessity of revitalising extension services, which serve as an intermediary profession connecting research findings from academics to end-users. In many low- and middle-income countries (LMICs), the combination of insufficient funding for veterinary healthcare systems and weak authoritarian capabilities hinders attempts to inspire diligent usage of antimicrobials and thwart antimicrobial resistance (AMR) in the agriculture industry (van Boeckel, Pires, Silvester, Zhao, Song, Criscuolo, Gilbert, Bonhoeffer, & Laxminarayan, 2020).

In the future, the implementation of multisectoral National Action Plans will be directed by the Tripartite Collaboration on AMR, which comprises the Food and Agriculture Organisation (FAO), the World Organisation for Animal Health (OIE), and the World Health Organisation (WHO). National Action Plans establish a set of objectives aimed at enhancing understanding of antimicrobial resistance (AMR) and associated risks, building the capability to track and evaluate the use of antimicrobials and AMR, reinforcing governance, and advocating for responsible use of antimicrobials in the public and animal health domains (T. P. Van Boeckel et al., 2019). Nevertheless, the lack of readily available animal health specialists hinders the effective execution of these strategies in the cattle industry.

The panellists and listeners emphasised the need for enhancing veterinary services and receiving sufficient support from the government. They recommended that the government should effectively strengthen local government regions by recruiting proficient veterinarians, thereby ensuring easy access to animal health care. Importantly, they suggested implementing frequent antimicrobial stewardship training and conducting lessons on sound farming methods in cattle production. Lastly, in conjunction with a One Health strategy, they called for the establishment of a multi-stakeholder forum consisting of key ministries, academia, farmers, marketers, exporters, and value chain actors to facilitate wider consultations. This will enhance the process of generating creative ideas and formulating strategies to enhance the industry and boost the export capacity of livestock and its associated products, in accordance with the aspirations of farmers.

The study results have validated the need to enhance public education and media engagement about the practice of antimicrobials and the development of resistance among livestock farmers. This study has demonstrated that these interactions are vital in fostering modifications in behavior among farmers. Behavior modification techniques that primarily depend on top-down measures, such as the enforcement of new rules, are improbable to result in extensive and enduring alterations in the utilisation of antimicrobials in low- and middle-income countries (LMICs). This is a result of the constraints in the existing supervisory capabilities and animal health services in these nations. In addition, top-down techniques frequently overlook and neglect the interests and concerns of the parties concerned (O'Mara-Eves et al., 2015).

While initiatives that are top-down can be implemented on a large scale and are easier to manage in situations with rigorous oversight and execution, they typically demand additional funding, can lead to impractical solutions with unforeseen repercussions, and are harder to maintain over time. Conversely, stakeholder support programs that are created through a

concerted route with the stakeholders they aim to assist, have the advantage of being jointly developed. This enhances the feasibility and enhances the efficacy and durability of the stakeholders' implementation. Our study found that the bottom-up approach is not only more efficient in terms of resources, but also efficient in using smaller 'seed' stakeholder groups to start a program for change. This method facilitates the spread of expertise and innovative practices among professionals and social circles, thereby engaging other individuals and groups with a vested interest.

Although our findings indicate the importance of implementing grassroots approaches to combat antimicrobial resistance (AMR) at the level of individual healthcare providers or users, it is evident that resource-limited countries must also make significant structural adjustments to eliminate obstacles and provide a supportive environment for individual-level interventions. Public engagement, whether launched by authorities, launched by the public, or an amalgam of both, is not enough by itself to achieve alterations to behavioural approaches geared towards promoting culpable intake of antimicrobials. It is crucial to also take into account the duties of agrovets and local residents in facilitating the transition towards healthier farming methods (Adhikari et al., 2020). These interventions should be based on a bottom-up method that finds out what people who use drugs know, how they feel, and what they do.

CONCLUSION AND RECOMMENDATIONS

Due to location and/or budgetary constraints, animal health professionals are typically inaccessible to livestock producers, who make resolutions on antimicrobial use with narrow or no input, according to this study. In light of these facts, programs aiming at promoting responsible use practices in the near future need to zero in on farm settings, where judgements on animal healthcare are taken, and employ proven modes of communication if they are to have any effect. It is recommended that livestock farmers and animal health experts' team up on a regular basis to create awareness through the media on the implications of antimicrobial use and resistance on livestock production, humans and the environment. The government should increase the staff strength of veterinary officers in the two districts to ensure easy accessibility of farmers to the services of the officers. Unless there is an adequate number of veterinarians in the livestock sectors who can offer high-quality and easily available services, including correct information on responsible drug use practices, the responsibility of giving veterinary advice and care will continue to fall on fellow community members and workers in agricultural veterinary shops. By conducting this research in multiple social and commercial settings, we can gather the required proof to create and roll out specific interventions aimed at changing behaviour and reducing antimicrobial resistance (AMR) on a worldwide basis.

Author Contributions

Conceptualization: Eric Koka, Audrey Gadzekpo
Data curation: Eric Koka, Audrey Gadzekpo
Formal analysis: Eric Koka
Funding acquisition: Audrey Gadzekpo
Investigation: Audrey Gadzekpo
Methodology: Eric Koka, Audrey Gadzekpo

Project administration: Audrey Gadzekpo
Visualization: Eric Koka
Writing – original draft: Eric Koka
Writing – review & editing: Eric Koka, Audrey Gadzekpo

FUNDING

This research was funded by a grant from PANDORA.

ACKNOWLEDGMENTS

The authors would like to thank the key informants and participants in the two districts. We are particularly grateful to Dr. Kofi Afakye and Dr. Bashiru Boi Kikimoto for their immerse support in helping us to contact the key informants to collect data.

Conflicts of Interest

No conflict of interest has been disclosed by the writers. The sponsors were not involved in any way with the study's planning, execution, analysis, interpretation, manuscript droughting, or publication decisions.

REFERENCE

Adhikari, B., Pell, C., & Cheah, P. Y. (2020). Community engagement and ethical global health research. Global Bioethics, 31(1). https://doi.org/10.1080/11287462.2019.1703504

Afema, J. A., Byarugaba, D. K., Shah, D. H., Atukwase, E., Nambi, M., & Sischo, W. M. (2016). Potential sources and transmission of salmonella and antimicrobial resistance in Kampala, Uganda. PLoS ONE, 11(3). https://doi.org/10.1371/journal.pone.0152130

Allotey, P. A., & Harel, O. (2019). Multiple Imputation for Incomplete Data in Environmental Epidemiology Research. In Current environmental health reports (Vol. 6, Issue 2). https://doi.org/10.1007/s40572-019-00230-y

Auta, A., Hadi, M. A., Oga, E., Adewuyi, E. O., Abdu-Aguye, S. N., Adeloye, D., Strickland-Hodge, B., & Morgan, D. J. (2019). Global access to antibiotics without prescription in community pharmacies: A systematic review and meta-analysis. Journal of Infection, 78(1). https://doi.org/10.1016/j.jinf.2018.07.001

Bebell, L. M., & Muiru, A. N. (2014). Antibiotic use and emerging resistance: How can resource-limited countries turn the tide? In Global Heart (Vol. 9, Issue 3). https://doi.org/10.1016/j.gheart.2014.08.009

Caudell, M. A., Dorado-Garcia, A., Eckford, S., Creese, C., Byarugaba, D. K., Afakye, K., Chansa-Kabali, T., Fasina, F. O., Kabali, E., Kiambi, S., Kimani, T., Mainda, G., Mangesho, P. E., Chimpangu, F., Dube, K., Kikimoto, B. B., Koka, E., Mugara, T., Rubegwa, B., & Swiswa, S. (2020). Towards a bottom-up understanding of antimicrobial use and resistance on the farm: A knowledge, attitudes, and practices survey across livestock systems in five African countries. PLoS ONE, 15(1). https://doi.org/10.1371/journal.pone.0220274

Caudell, M. A., Quinlan, M. B., Subbiah, M., Call, D. R., Roulette, C. J., Roulette, J. W., Roth, A., Matthews, L., & Quinlan, R. J. (2017). Antimicrobial use and veterinary care among

agro-pastoralists in Northern Tanzania. PLoS ONE, 12(1). https://doi.org/10.1371/journal.pone.0170328

Charoenboon, N., Haenssgen, M. J., Warapikuptanun, P., Xayavong, T., & Khine Zaw, Y. (2019). Translating antimicrobial resistance: a case study of context and consequences of antibiotic-related communication in three northern Thai villages. Palgrave Communications, 5(1). https://doi.org/10.1057/s41599-019-0226-9

Collignon, P., Beggs, J. J., Walsh, T. R., Gandra, S., & Laxminarayan, R. (2018). Anthropological and socioeconomic factors contributing to global antimicrobial resistance: a univariate and multivariable analysis. The Lancet Planetary Health, 2(9). https://doi.org/10.1016/S2542-5196(18)30186-4

Davies, J. (1996). Origins and evolution of antibiotic resistance. In Microbiología (Madrid, Spain) (Vol. 12, Issue 1). https://doi.org/10.1128/mmbr.00016-10

Day, M. J., Hopkins, K. L., Wareham, D. W., Toleman, M. A., Elviss, N., Randall, L., Teale, C., Cleary, P., Wiuff, C., Doumith, M., Ellington, M. J., Woodford, N., & Livermore, D. M. (2019). Extended-spectrum β-lactamase-producing Escherichia coli in human-derived and foodchain-derived samples from England, Wales, and Scotland: an epidemiological surveillance and typing study. The Lancet Infectious Diseases, 19(12). https://doi.org/10.1016/S1473-3099(19)30273-7

Deo, N., & Anjankar, A. (2023). Artificial Intelligence With Robotics in Healthcare: A Narrative Review of Its Viability in India. Cureus. https://doi.org/10.7759/cureus.39416

Founou, L. L., Founou, R. C., & Essack, S. Y. (2016). Antibiotic resistance in the food chain: A developing country-perspective. In Frontiers in Microbiology (Vol. 7, Issue NOV). https://doi.org/10.3389/fmicb.2016.01881

Guenther, S., Ewers, C., & Wieler, L. H. (2011). Extended-spectrum beta-lactamases producing E. coli in wildlife, yet another form of environmental pollution? In Frontiers in Microbiology (Vol. 2, Issue DEC). https://doi.org/10.3389/fmicb.2011.00246

Gundran, R. S., Cardenio, P. A., Salvador, R. T., Sison, F. B., Benigno, C. C., Kreausukon, K., Pichpol, D., & Punyapornwithaya, V. (2020). Prevalence, Antibiogram, and Resistance Profile of Extended-Spectrum β-Lactamase-Producing Escherichia coli Isolates from Pig Farms in Luzon, Philippines. Microbial Drug Resistance, 26(2). https://doi.org/10.1089/mdr.2019.0019

Haenssgen, M. J., Charoenboon, N., Thavethanutthanawin, P., & Wibunjak, K. (2021). Tales of treatment and new perspectives for global health research on antimicrobial resistance. Medical Humanities, 47(4). https://doi.org/10.1136/medhum-2020-011894

Haenssgen, M. J., Xayavong, T., Charoenboon, N., Warapikuptanun, P., & Zaw, Y. K. (2018). The consequences of AMR education and awareness raising: Outputs, outcomes, and behavioural impacts of an antibiotic-related educational activity in lao PDR. Antibiotics, 7(4). https://doi.org/10.3390/antibiotics7040095

Hendriksen, R. S., Munk, P., Njage, P., van Bunnik, B., McNally, L., Lukjancenko, O., Röder, T., Nieuwenhuijse, D., Pedersen, S. K., Kjeldgaard, J., Kaas, R. S., Clausen, P. T. L. C., Vogt, J. K., Leekitcharoenphon, P., van de Schans, M. G. M., Zuidema, T., de Roda Husman, A. M., Rasmussen, S., Petersen, B., … Aarestrup, F. M. (2019). Global monitoring of antimicrobial resistance based on metagenomics analyses of urban sewage. Nature Communications, 10(1). https://doi.org/10.1038/s41467-019-08853-3

Hoffman, S. J., Caleo, G. M., Daulaire, N., Elbe, S., Matsoso, P., Mossialos, E., Rizvi, Z., & Røttingen, J.-A. (2015). Strategies for achieving global collective action on antimicrobial resistance. Bulletin of the World Health Organization, 93(12). https://doi.org/10.2471/blt.15.153171

Jimah, T., Fenny, A. P., & Ogunseitan, O. A. (2020). Antibiotics stewardship in Ghana: a cross-sectional study of public knowledge, attitudes, and practices among communities. One Health Outlook, 2(1). https://doi.org/10.1186/s42522-020-00021-8

Katakweba, A. A. S., Møller, K. S., Muumba, J., Muhairwa, A. P., Damborg, P., Rosenkrantz, J. T., Minga, U. M., Mtambo, M. M. A., & Olsen, J. E. (2015). Antimicrobial resistance in faecal samples from buffalo, wildebeest and zebra grazing together with and without cattle in Tanzania. Journal of Applied Microbiology, 118(4). https://doi.org/10.1111/jam.12738

Khan, M. S., Durrance-Bagale, A., Legido-Quigley, H., Mateus, A., Hasan, R., Spencer, J., & Hanefeld, J. (2019). LMICs as reservoirs of AMR': a comparative analysis of policy discourse on antimicrobial resistance with reference to Pakistan. Health Policy and Planning, 34(3). https://doi.org/10.1093/heapol/czz022

Kinnison, T., May, S. A., & Guile, D. (2015). Veterinary team interactions, part one: The practice effect. Veterinary Record, 177(16). https://doi.org/10.1136/vr.103312

Landers, T. F., Cohen, B., Wittum, T. E., & Larson, E. L. (2012). A review of antibiotic use in food animals: Perspective, policy, and potential. In Public Health Reports (Vol. 127, Issue 1). https://doi.org/10.1177/003335491212700103

Lele, U., & Goswami, S. (2021). The Food and Agriculture Organization of the United Nations. In Food for All: International Organizations and the Transformation of Agriculture. https://doi.org/10.1093/oso/9780198755173.003.0010

Levy, S. B., & Bonnie, M. (2004). Antibacterial resistance worldwide: Causes, challenges and responses. In Nature Medicine (Vol. 10, Issue 12S). https://doi.org/10.1038/nm1145

Mather, A. E., Reid, S. W. J., Maskell, D. J., Parkhill, J., Fookes, M. C., Harris, S. R., Brown, D. J., Coia, J. E., Mulvey, M. R., Gilmour, M. W., Petrovska, L., De Pinna, E., Kuroda, M., Akiba, M., Izumiya, H., Connor, T. R., Suchard, M. A., Lemey, P., Mellor, D. J., … Thomson, N. R. (2013). Distinguishable epidemics of multidrug-resistant Salmonella typhimurium DT104 in different hosts. Science, 341(6153). https://doi.org/10.1126/science.1240578

Mitchell, J., Cooke, P., Ahorlu, C., Arjyal, A., Baral, S., Carter, L., Dasgupta, R., Fieroze, F., Fonseca-Braga, M., Huque, R., Lewycka, S., Kalpana, P., Saxena, D., Tomley, F., Tsekleves, E., Vu Thi Quynh, G., & King, R. (2022). Community engagement: The key to tackling Antimicrobial Resistance (AMR) across a One Health context? Global Public Health, 17(11). https://doi.org/10.1080/17441692.2021.2003839

Okeke, I. N., Laxminarayan, R., Bhutta, Z. A., Duse, A. G., Jenkins, P., O'Brien, T. F., Pablos-Mendez, A., & Klugman, K. P. (2005). Antimicrobial resistance in developing countries. Part I: Recent trends and current status. In Lancet Infectious Diseases (Vol. 5, Issue 8). https://doi.org/10.1016/S1473-3099(05)70189-4

O'Mara-Eves, A., Brunton, G., Oliver, S., Kavanagh, J., Jamal, F., & Thomas, J. (2015). The effectiveness of community engagement in public health interventions for disadvantaged

groups: A meta-analysis. BMC Public Health, 15(1). https://doi.org/10.1186/s12889-015-1352-y

Omulo, S., Thumbi, S. M., Lockwood, S., Verani, J. R., Bigogo, G., Masyongo, G., & Call, D. R. (2017). Evidence of superficial knowledge regarding antibiotics and their use: Results of two cross-sectional surveys in an urban informal settlement in Kenya. PLoS ONE, 12(10). https://doi.org/10.1371/journal.pone.0185827

Rifkin, S. B. (2014). Examining the links between community participation and health outcomes: A review of the literature. In Health Policy and Planning (Vol. 29). https://doi.org/10.1093/heapol/czu076

Robinson, T. P., Bu, D. P., Carrique-Mas, J., Fèvre, E. M., Gilbert, M., Grace, D., Hay, S. I., Jiwakanon, J., Kakkar, M., Kariuki, S., Laxminarayan, R., Lubroth, J., Magnusson, U., Ngoc, P. T., Van Boeckel, T. P., & Woolhouse, M. E. J. (2016). Antibiotic resistance is the quintessential One Health issue. In Transactions of the Royal Society of Tropical Medicine and Hygiene (Vol. 110, Issue 7). https://doi.org/10.1093/trstmh/trw048

Seale, A. C., Gordon, N. C., Islam, J., Peacock, S. J., & Scott, J. A. G. (2017). AMR surveillance in low and middle-income settings - A roadmap for participation in the Global Antimicrobial Surveillance System (GLASS). Wellcome Open Research, 2. https://doi.org/10.12688/wellcomeopenres.12527.1

Thornber, K., Huso, D., Rahman, M. M., Biswas, H., Rahman, M. H., Brum, E., & Tyler, C. R. (2019). Raising awareness of antimicrobial resistance in rural aquaculture practice in Bangladesh through digital communications: a pilot study. Global Health Action, 12(sup1). https://doi.org/10.1080/16549716.2020.1734735

Van Boeckel, T. P., Pires, J., Silvester, R., Zhao, C., Song, J., Criscuolo, N. G., Gilbert, M., Bonhoeffer, S., & Laxminarayan, R. (2019). Global trends in antimicrobial resistance in animals in low- And middle-income countries. Science, 365(6459). https://doi.org/10.1126/science.aaw1944

van Boeckel, T., Pires, J., Silvester, R., Zhao, C., Song, J., Criscuolo, N., Gilbert, M., Bonhoeffer, S., & Laxminarayan, R. (2020). Global trends in antimicrobial resistance in animals in low- and middle-income countries. International Journal of Infectious Diseases, 101. https://doi.org/10.1016/j.ijid.2020.09.086

Van Katwyk, S. R., Balasegaram, M., Boriello, P., Farrar, J., Giubilini, A., Harrison, M., Kieny, M. P., Kirchhelle, C., Liu, J., Outterson, K., Pate, M. A., Poirier, M., Røttingen, J. A., Savulescu, J., Sugden, R., Thamlikitkul, V., Weldon, I., Davies, S., & Hoffman, S. J. (2019). A roadmap for sustainably governing the global antimicrobial commons. In The Lancet (Vol. 394, Issue 10211). https://doi.org/10.1016/S0140-6736(19)32767-9

Van Katwyk, S. R., Wilson, L., Weldon, I., Hoffman, S. J., & Poirier, M. J. P. (2022). Adopting a Global AMR Target within the Pandemic Instrument Will Act as a Catalyst for Action. Journal of Law, Medicine and Ethics, 50. https://doi.org/10.1017/jme.2022.101

Zinsstag, J., Schelling, E., Waltner-Toews, D., & Tanner, M. (2011). From "one medicine" to "one health" and systemic approaches to health and well-being. Preventive Veterinary Medicine, 101(3–4). https://doi.org/10.1016/j.prevetmed.2010.07.003