

Contested waters: a one health exploration of antimicrobial resistance through cultural and public health lenses

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Abstract. This study investigates the complex dynamics of antimicrobial resistance (AMR) at the water-fish-human interface in Lakewood, Zamboanga del Sur, Philippines, through a One Health lens. Recognizing AMR as a multifaceted global health concern, it examines both environmental and sociocultural dimensions that contribute to the emergence and persistence of resistance. The research assessed the presence of antibiotic-resistant bacteria (ARB), *Escherichia coli*, *Salmonella* spp., and *Vibrio cholerae* in local water sources and aquatic food systems, while also exploring community knowledge, health behaviors, and cultural practices that influence AMR risk. Using a qualitative design, data were gathered through key informant interviews (KIIs) and focus group discussions (FGDs) in two communities adjacent to Lakewood Lake. Thematic analysis revealed five interrelated domains: (1) reliance on untreated water sources, (2) continued fish consumption despite possible contamination, (3) recurring waterborne illnesses such as diarrhea and amoebiasis, (4) inconsistent antibiotic use practices, and (5) persistent reliance on traditional herbal remedies. While some respondents followed prescribed antibiotic regimens, misconceptions about their proper use and a preference for indigenous treatments were widespread. The study highlights how environmental exposure and sociocultural factors converge to facilitate the transmission of AMR. By integrating cultural practices into AMR inquiry, this research offers a novel, community-grounded perspective often overlooked in One Health discussions. It calls for strengthened environmental surveillance, culturally responsive AMR education, improved water, sanitation, and hygiene (WASH) infrastructure, and holistic interventions that bridge biomedical and traditional health systems. Ultimately, the study contributes to the growing discourse on localized, multisectoral strategies for addressing AMR in underserved rural communities.

Key Words: antimicrobial resistance, one health approach, waterborne diseases, community health practices, Lake Lakewood.

Introduction. Antimicrobial resistance (AMR) has emerged as one of the most serious global health concerns, no longer confined to clinical or agricultural boundaries. Extensive and often inappropriate antibiotic use has driven the emergence and spread of AMR, an international health crisis marked by the reduced efficacy of antimicrobial treatments (Al-Khalaifah 2025). Additionally, the global rise of antibiotic resistance is increasingly recognized as an environmental as well as a clinical crisis, with tropical freshwater ecosystems emerging as reservoirs of antibiotic-resistant bacteria (ARB) due to

contamination from sources like untreated municipal sewage, agricultural runoff, hospital effluents, natural reservoirs, and wild fauna (Papoola et al 2025). Its impact is now evident across natural ecosystems and social environments. The growing prevalence of antibiotic-resistant organisms, such as *Escherichia coli*, *Salmonella enterica* (particularly *S. enterica* serovar Typhimurium), and *Vibrio cholerae*, made the treatment of common infections increasingly difficult, resulting in longer illness duration, higher healthcare costs, and a greater risk of death (Bürgmann et al 2018; WHO 2019). Although surveillance in hospitals and farms has advanced significantly, limited attention has been given to the environmental and behavioral dimensions of AMR, especially in remote areas where clean water, healthcare access, and public health education remain inadequate (Singer et al 2016).

In rural communities, the link between water, aquatic life, and human activity creates a unique channel through which AMR can be transmitted. AMR is a critical global problem affecting humans, the environment, and animals. This is related to each of these three components due to the irresponsible and excessive use of antimicrobials in various sectors like agriculture, livestock, and human medicine (Velazquez-Meza et al 2022). Lakes and rivers exposed to untreated waste, poorly managed sanitation, and antibiotic runoff from households and aquaculture become hotspots for resistant bacteria and resistance genes (Cabello 2006). Within these contaminated settings, routine human interactions with water sources and local food items contribute to a cycle of infection and antibiotic reliance, thus accelerating the problem of resistance.

One such area is Lakewood in Zamboanga del Sur, located in the southern Philippines. As the largest freshwater lake in the province, it serves several purposes, providing water for daily use, supporting household activities, and serving as a food source through fishing. Despite its importance, the lake is at risk due to improper waste disposal, open defecation, and possibly uncontrolled antibiotic usage in homes and aquaculture settings. These stressors may create the ideal environment for AMR to thrive and spread (Suson 2019).

To understand the interconnected factors influencing AMR in Lakewood, this study employed the One Health framework, which highlights the interdependence of humans, animals, and their shared environment (Walsh 2018). It assessed the extent of bacterial and chemical contamination in the lake and fish, alongside community perspectives on antibiotic use and water, sanitation, and hygiene (WASH).

Using both microbiological analyses and qualitative methods such as interviews and focus group discussions (FGDs), the study integrated biological evidence with local experiences to capture the human-environment interface of AMR. Future solutions to address AMR must focus on innovation, public engagement, and multi-sectoral collaboration to tackle the rising tide of resistance (Msemakweli et al 2024). By situating resistance within the lived realities of a rural community, it provides contextual insights often missing from hospital- or farm-based studies and underscores the need for culturally grounded interventions in the Philippine One Health response.

Material and Method

Study area. This study was conducted in two communities, Poblacion and Bag-ong Kahayag, in the municipality of Lakewood, Zamboanga del Sur, Philippines. Lakewood Lake, the largest inland body of water in the province, plays a central role in the community's daily life, serving as a source of potable water, food, and livelihood. However, the lake is also vulnerable to contamination due to the discharge of untreated municipal wastewater and the prevalence of poor sanitation practices.



Figure 1. Research the locale and distance from Lakewood Lake.

Figure 1 illustrates the Spatial map showing the relative locations of the two study sites, Poblacion Community (Nearest) and Bag-ong Kahayag Community (Farthest), in relation to Lakewood Lake, Zamboanga del Sur, Philippines. Each site is denoted by a distinct marker: black for Lakewood Lake, green for Poblacion Community, and blue for Bag-ong Kahayag Community. Dashed black lines indicate approximate linear distances from the lake, with Poblacion located about 0.35 km away and Bag-ong Kahayag roughly 0.70 km distant. The spatial layout highlights the varying proximity of communities to the lake, providing contextual evidence of their differing exposure to potential AMR sources within the water-fish-human interface. This visualization supports the study's discussion on environmental pathways and community-level risk factors contributing to AMR transmission in rural aquatic ecosystems.

Within the municipality of Lakewood (population 21,559; ~ 107 persons km^{-2}), the study focused on two communities with contrasting characteristics. Bag-ong Kahayag, with 1,938 residents (~ 4.9 persons per household) and a slow growth rate ($\sim 0.6\% \text{ yr}^{-1}$), represents a comparatively remote rural settlement with potentially limited services. In contrast, Poblacion serves as the municipal centre and shows a modest youth-skewed age profile (13.0% aged 10-14) and access to municipal institutions; however, the municipality's low scores for health- and school-service capacity suggest that even the "center" community operates with constrained infrastructure. These socioeconomic and demographic conditions provide key context for interpreting water-use behaviours, fish consumption patterns, and antibiotic practices in a One Health framework of AMR.

Research design. A qualitative research approach was utilized to investigate community knowledge, attitudes, and practices concerning AMR and WASH behaviors. The methodology approach was derived from the Philippine Approach to Total Sanitation (PhATS) Baseline Assessment created by the United Nations Children's Fund (REACH-UNICEF 2015). The study aimed to record local inhabitants' perceptions and management of AMR-related dangers linked to contaminated water, as well as to evaluate the accessibility and utilization of WASH facilities within their communities. A total of 15 participants were purposively selected, comprising both males and females aged 21-65 years, representing varied occupations such as fisherfolk, homemakers, vendors, and barangay health workers. The number was considered sufficient upon reaching thematic saturation, where no new insights emerged during successive interviews. The interview guide was culturally adapted by translating key terms into Cebuano and incorporating locally relevant examples related to water use, health-seeking behaviors, and indigenous healing practices to ensure comprehension and contextual authenticity of responses.

Data collection. Data were collected via key informant interviews (KIIs) and FGDs, including health service professionals and community members. Fifteen (15) participants participated in the study. These qualitative instruments yielded comprehensive, contextual insights on local social norms, health beliefs, accessibility to health care, and the community's involvement with WASH programs and AMR surveillance initiatives. FGDs were executed in the two chosen barangays, while KIIs included people from the Barangay Health Stations and other pertinent stakeholders. An interview guide featuring open-ended questions was employed to extract narratives concerning various themes, including water source utilization, antibiotic consumption trends, traditional health practices, and perceived deficiencies in local WASH and AMR-related activities. Before field implementation, all instruments were pilot-tested and verified to guarantee dependability and cultural suitability.

Ethical considerations. The research obtained ethical approval from a Research Ethics Committee recognized by the Philippine Health Research Ethics Board (PHREB). All ethical protocols were meticulously adhered to, including the acquisition of written informed consent from all participants, ensuring voluntary participation, and compliance with Republic Act No. 10173, the Data Privacy Act of 2012, to preserve confidentiality and protect participant rights. The data collection was conducted by a team of qualified male and female enumerators who were comprehensively instructed in ethical research practices and qualitative field methodology. Specifically, the study was reviewed and approved by the Mindanao State University-Buug Campus Research Ethics Committee, a PHREB-accredited body. Participants were informed of their rights and provided with small tokens of appreciation (e.g., food packs) to acknowledge their time and contribution without coercion or undue influence. This ensured both ethical transparency and culturally appropriate engagement with the local communities.

Data documentation and supplementary materials. All interviews and discussions were audio-recorded with informed consent and later transcribed for thematic analysis. To promote openness and improve knowledge transmission, additional documents will be available via a digital platform. The materials comprise video documentation, including interview excerpts and fieldwork, infographics that encapsulate key thematic findings, geospatial maps of sampling sites, and links to pertinent institutional resources, such as those from the World Health Organization, Food and Agriculture Organization, Department of Health, National Center for Biotechnology Information, and the Research Institute for Tropical Medicine. These tools seek to enhance public access to research findings and foster a greater comprehension of AMR and One Health programs in rural areas of the Philippines.

Results. The findings of this study are thematically structured to illustrate the lived experiences and views of community members from two sites next to Lakewood Lake, B Poblacion (closest to the lake), and Bag-ong Kahayag (farthest from the lake). Themes encompass: (1) water sources, (2) fish eating, (3) waterborne diseases, (4) awareness and utilization of antibiotics, and (5) alternative health practices. Each issue is situated within the wider discussion on AMR and environmental health.

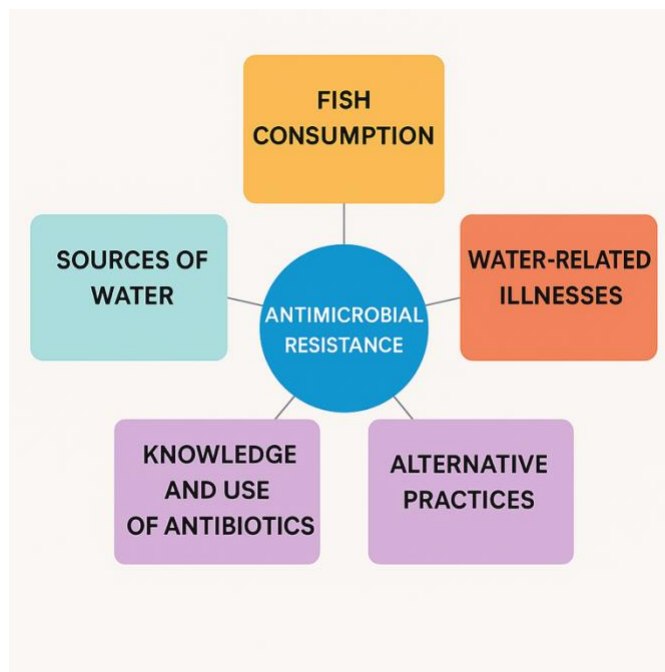


Figure 2. Thematic framework of community factors influencing AMR in Lakewood, Zamboanga del Sur.

The thematic analysis (Figure 2) illustrates how environmental conditions, behaviors, and beliefs intersect to shape AMR in the Lakewood communities. Participants from both Poblacion and Bag-ong Kahayag described reliance on natural water sources and modest fish consumption despite awareness of contamination risks, reflecting both necessity and limited alternatives. Waterborne illnesses such as diarrhea and amoebiasis prompted inconsistent health-seeking behaviors, including incomplete antibiotic courses and self-medication. Herbal treatments, such as snakeweed and five-leaf chaste tree, were widely used, not merely as tradition but as pragmatic responses to limited access to formal care. Although antibiotic awareness was present, knowledge gaps and varying adherence practices were more evident in the rural Bag-ong Kahayag community than in semi-urban Poblacion, where pharmacy and clinic access were better. These patterns reveal how sociocultural adaptation, economic need, and resource disparities contribute to AMR transmission across the water-fish-human interface, underscoring the necessity of community-specific, culturally informed health interventions.

Sources of water. Water sources are central to AMR transmission, as surface and groundwater can harbor resistant bacteria introduced through human, agricultural, and environmental contamination (Carvalho & Santos 2016). Recent evidence further shows that aquatic environments function as active reservoirs where ARB and resistance genes can persist, exchange, and evolve, particularly under conditions of poor sanitation and organic loading (Milijasevic et al 2024). In both barangays, respondents reported relying on multiple water sources for drinking, cooking, and household chores, including wells (poso), springs, faucets, and commercial refilling stations. Despite this diversity, many informants expressed concerns about water safety, particularly during the rainy season when turbidity, odor, and contamination were most noticeable. These experiences highlight both environmental vulnerability and the community's limited control over water quality, reinforcing the potential for repeated exposure to resistant organisms.

"The source of our water here is from the well. In the well, there is something to drink, and some are not safe to drink." (Informant #1, Poblacion)

"Others buy mineral water to drink during the rainy season because the tap water is muddy." (Informant #10, Bag-ong Kahayag)

These seemingly simple remarks reveal nuanced perceptions of water safety and accessibility within two contrasting communities. In Poblacion, proximity to municipal water systems and refilling stations fosters a heightened awareness of contamination risks, prompting preventive behaviors such as boiling, filtering, or purchasing mineral water. This indicates both access to resources and a form of health literacy that links cleanliness with disease prevention.

Conversely, in Bag-ong Kahayag, where households depend largely on communal wells and natural springs, trust in water sources is mediated by necessity rather than confidence. Seasonal turbidity and odor, often treated as ordinary occurrences, illustrate how environmental vulnerability has shaped a collective tolerance toward risk. Such normalization of water insecurity points to structural inequities in water infrastructure and highlights how cultural adaptation becomes a coping mechanism in resource-limited settings.

These accounts reveal that the brevity of their responses, such as noting that some water “is not safe to drink”, belies a lived understanding of environmental vulnerability and resource inequality. The subtle contrasts between Poblacion’s precautionary behaviors and Bag-ong Kahayag’s reliance on natural sources suggest that access, affordability, and local perception jointly shape exposure to resistant bacteria. This is consistent with existing literature noting that environmental exposure to waterborne resistant bacteria may lead to infections in the skin, gastrointestinal tract, and respiratory systems (Kanamori et al 2016).

Fish consumption. As aquatic systems are major reservoirs for microbial activity, they also play a key role in AMR development and spread. Fish and shellfish from contaminated water bodies may carry antibiotic residues or resistance genes, contributing to the transfer of resistance traits from aquatic pathogens to humans (Rhodes et al 2000;Cabello 2006). In the present study, residents confirmed that fishing in Lakewood Lake continues, albeit on a modest scale:

“We rarely get fish from the lake, like tilapia.” (Participant #16, Poblacion)

“What is usually caught in the lake is ‘porang’ (small prawns).” (Participant #17, Poblacion)

Although these statements seem descriptive, they uncover deeper dimensions of livelihood, sustenance, and environmental perception among Lakewood residents. In Poblacion, reduced fishing activity reflects both shifting economic structures and emerging environmental awareness. Access to alternative income sources, such as small businesses or employment in nearby towns, allows households to distance themselves from potential health risks associated with lake consumption. This behavioral shift may signify a growing recognition of contamination, albeit shaped by improved socioeconomic capacity to choose safer food sources.

By contrast, in Bag-ong Kahayag, dependence on the lake’s aquatic resources remains strong, underscoring how subsistence economies anchor daily nutrition and cultural food practices. Despite visible signs of environmental degradation, such as murky water or reduced fish diversity, residents continue to consume locally caught fish and prawns, often without thorough cleaning or sufficient cooking. This persistence reflects a delicate balance between survival and safety, where immediate food needs outweigh long-term health considerations.

These behaviors illustrate a critical pathway for AMR transmission through the food chain. When lake organisms are exposed to contaminated water containing antibiotic residues or resistant bacteria, they can become vectors for human exposure. The findings thus reveal how ecological vulnerability, economic necessity, and cultural continuity converge to shape AMR risks within the water-fish-human interface. Understanding these intersections is essential for designing One Health interventions that are both culturally grounded and socially responsive.

Water-related illnesses. Both communities reported frequent cases of waterborne illnesses such as diarrhea, amoebiasis, and dengue, especially during the rainy season. This trend aligns with prior studies linking compromised water quality to disease outbreaks (Xi et al 2009; Gomez-Alvarez et al 2012).

"During the rainy season, the most common diseases of people here are diarrhea, amoeba, and LBM." (Informant #4)

Although succinct, this statement captures the intersection of environmental exposure, sanitation practices, and health vulnerability. Community accounts revealed that heavy rains frequently cause flooding, contaminating wells and household containers and compelling families to use untreated water for daily needs such as cooking and washing. In Poblacion, proximity to drainage systems heightens exposure to runoff carrying waste and debris, while in Bag-ong Kahayag, inadequate sanitation infrastructure and open defecation further compromise water quality.

Residents' recognition of "dirty water" as a source of illness demonstrates experiential awareness grounded in repeated outbreaks. However, their limited understanding of microbial transmission points to persistent knowledge gaps in environmental health literacy. This disjunction between awareness and scientific understanding underscores the need for culturally sensitive health education and improved WASH interventions. More importantly, it reveals how structural inequities, such as poor infrastructure and limited access to safe water, translate environmental risks into recurring patterns of disease, perpetuating conditions conducive to AMR.

Although diarrheal cases were the most commonly reported, the mention of mosquito-borne diseases such as dengue points to broader environmental health challenges and the need for integrated WASH and vector control interventions. Furthermore, prior research indicates that tap water may contain higher loads ARB than untreated sources due to biofilm formation and contamination within aging distribution systems (Vaz-Moreira et al 2012; Manaia et al 2018). Together, these findings underscore the interconnectedness of water quality, infrastructure, and health behaviors in sustaining AMR risks within rural and semi-urban settings.

Knowledge and use of antibiotics. Community members across both communities displayed basic awareness of antibiotics, recognizing them as medicines used to treat infections. Commonly used drugs included amoxicillin, mefenamic acid, cephalexin, and co-trimoxazole.

"In here, we use amoxicillin, mefenamic, and cephalexin." (Participant #30, Bag-ong Kahayag)

Although seemingly simple, this statement uncovers complex layers of understanding and practice surrounding antibiotic use in rural communities. Further discussion revealed that participants often blurred the distinction between antibiotics and common analgesics, reflecting a partial grasp of their pharmacological differences. This conflation suggests that antibiotic use is shaped less by biomedical literacy and more by habitual, experience-based knowledge of symptom relief.

In Poblacion, residents generally obtained antibiotics through formal prescriptions at local health centers, showing greater exposure to medical oversight. In contrast, households in Bag-ong Kahayag relied on informal access, purchasing antibiotics over the counter or sharing leftover medicines within families, particularly for recurring ailments such as coughs, fevers, and skin infections. Despite this, many participants still expressed trust in professional advice and claimed to follow prescribed dosages, indicating a coexistence of regulated and unregulated health behaviors.

These findings point to a nuanced pattern of "practical antibiotic knowledge," where biomedical awareness coexists with self-medication practices shaped by accessibility, economic constraints, and local health beliefs. Such behaviors, while adaptive in resource-

limited settings, heighten the risk of inappropriate antibiotic exposure and contribute to the persistence of AMR at the community level.

"We are not advised to take antibiotics carelessly. We follow what the doctor at the center says." (Participant #30)

This indicates growing awareness of proper antibiotic use, likely influenced by barangay health workers' campaigns and the presence of rural health units. Nonetheless, self-medication and incomplete antibiotic courses persist due to cost constraints and accessibility issues. The coexistence of medical compliance and informal access reveals a nuanced behavioral landscape, where biomedical instruction intersects with cultural norms of self-care. Nevertheless, informal access to antibiotics and over-the-counter dispensing without prescriptions remain national challenges.

Alternative practices. Participants also reported using local herbal remedies to treat common illnesses, especially during the COVID-19 pandemic when fear of injections and vaccine hesitancy were prevalent.

"When we have dengue, we drink it from the juice of snakeweed." (Participant #21)

"We use herbs to treat our ailments." (Participant #33)

Though brief, these statements reveal the enduring significance of traditional healing practices in the community's health culture. The frequent use of snakeweed, five-leaf chaste tree, peperomia, and wild ginger reflects not only familiarity with local ethnomedicine but also an intergenerational trust in nature-based remedies. Such practices are embedded within broader systems of meaning where health, illness, and healing are intertwined with cultural identity and environmental knowledge.

In Bag-ong Kahayag, reliance on herbal medicine often stemmed from limited financial means and the physical distance from formal health facilities, making traditional remedies both practical and symbolic of self-reliance. In Poblacion, however, herbal use was more complementary, serving as an adjunct to biomedical treatment rather than a substitute, suggesting a gradual integration of traditional and modern health beliefs.

These patterns illustrate how local pharmacological knowledge operates as a parallel health system, mediating the community's engagement with formal medicine. While such practices foster resilience and accessibility, they also raise concerns regarding potential interactions with antibiotics and the unverified use of plant-based treatments. Understanding these cultural logics is crucial for developing One Health interventions that respect indigenous knowledge while ensuring safe and rational health practices.

The herbal plants cited, such as snakeweed, five-leaf chaste tree, peperomia, and wild ginger, represent traditional knowledge systems that coexist with biomedical practices. While these alternatives may offer some benefits, their exclusive use without proper medical consultation can pose risks, especially for infections requiring antibiotic intervention. The preference for herbal remedies also reveals the socio-cultural dimension of health-seeking behavior, which must be considered when designing AMR education campaigns.

Discussion. This study examined AMR dynamics at the water-fish-human interface in a rural Philippine community, showing how environmental exposure, reliance on lake resources, and local treatment practices jointly shape antimicrobial risks. The findings advance One Health scholarship by highlighting how AMR in resource-limited settings is driven not only by microbial factors but also by everyday vulnerabilities, informal care practices, and gaps in rural health and WASH systems.

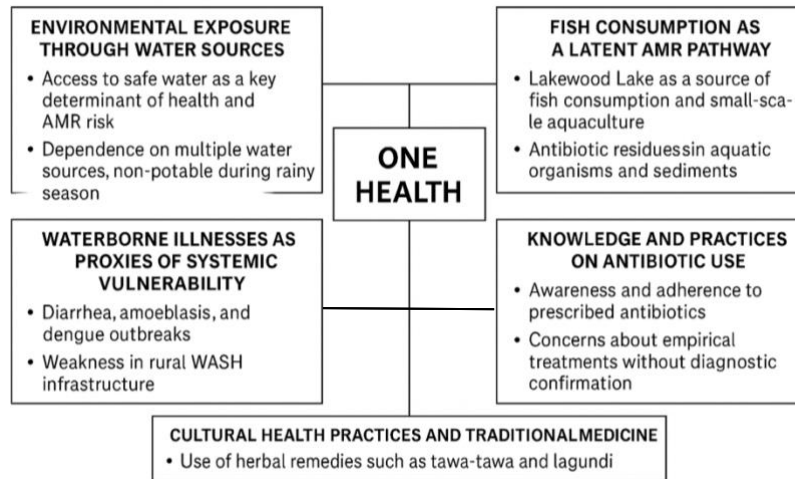


Figure 3. Interlinking pathways of AMR in a rural Philippine community: A one health perspective

Figure 3 illustrates the interconnected pathways of AMR observed in the Lakewood community. Environmental exposure through water sources emerged in accounts of relying on unsafe or multiple water sources, especially during the rainy season. Waterborne illnesses such as diarrhea, amoebiasis, and dengue were frequently reported and linked to gaps in rural WASH facilities. Fish consumption as a latent AMR pathway was reflected in the community’s daily reliance on Lake Lakewood for tilapia (*Oreochromis* spp.) and concerns about possible antibiotic residues in aquatic environments. Knowledge and practices on antibiotic use surfaced through reports of self-medication, sharing leftover antibiotics, and inconsistent adherence to prescriptions. Cultural health practices complemented these dynamics, as residents commonly used herbal remedies like snakeweed and five-leaf chaste tree alongside biomedical treatment. Together, these findings show how human, environmental, and animal health interactions jointly shape AMR risks in the community.

Environmental exposure through water sources. Environmental exposure through water sources emerged as a central driver of AMR vulnerability. In Lakewood, households relied on untreated or intermittently filtered water, a condition that heightened microbial exposure not only during the rainy season but also in everyday domestic use. While previous studies have linked inadequate WASH systems to the persistence of resistant organisms (Carvalho & Santos 2016; Kanamori et al 2016), the present findings extend this evidence by showing how localized water insecurity, shifting sources, inconsistent filtration practices, and community-level governance gaps create continuous rather than episodic exposure risks. These patterns reveal that rural WASH challenges are not simply infrastructural deficits but structural conditions that shape routine antimicrobial pressures. Strengthening community-managed, climate-resilient drinking-water systems is therefore essential to interrupting these locally embedded AMR pathways.

Fish consumption as a latent AMR pathway. Fish consumption emerged as a latent AMR pathway connecting household food practices to the microbial conditions of Lakewood’s aquatic ecosystem. Earlier studies show that antibiotic residues and resistant genes in fish, sediments, and aquatic bacteria can facilitate resistance transfer across species (Rhodes et al., 2000; Cabello, 2006). Although fish consumption in the community is modest, the mechanism remains relevant because households rely on the same lake for drinking, washing, and other daily needs, creating continuous environmental contact with potentially contaminated water. This dual dependence on food and water creates overlapping exposure points not captured in conventional WASH or AMR surveillance frameworks. The findings, therefore, highlight the need to integrate inland fisheries and small-scale aquaculture into AMR monitoring, especially in rural settings where risks arise from subsistence use rather than intensive fish production.

Waterborne illnesses as proxies of systemic vulnerability. Waterborne illnesses, particularly diarrhea, amoebiasis, and dengue, served as clear indicators of underlying WASH deficiencies in the community. Prior studies show that such infections often lead to increased antibiotic use and heightened selective pressure (Xi et al 2009; Gómez-Álvarez et al 2012), but the present findings make this cycle more explicit: episodes of gastrointestinal illness routinely prompted households to self-medicate or start antibiotics early, which, when repeated across seasons, created recurring windows for resistance to develop. These illnesses persisted despite efforts to boil or filter water, highlighting limitations in household-level treatment and revealing deeper structural problems in water accessibility and quality. Seasonal flooding and poor waste disposal further contaminated surface water, forcing residents to shift between multiple, often unsafe, sources. Although treated tap water can harbor resistant bacteria via pipeline biofilms (Vaz-Moreira et al 2012; Manaia et al 2018), local experiences showed that inconsistent supply and aging infrastructure pushed households toward alternative water options, sustaining continuous exposure. These patterns underscore the need for integrated interventions that improve WASH systems while embedding routine environmental and health surveillance to break the illness-antibiotic-AMR cycle.

Knowledge and practices on antibiotic use. Knowledge and practices on antibiotic use revealed a disconnect between what residents know and what their circumstances allow them to do. Although many participants could articulate correct instructions, such as completing a full course or avoiding leftover medicines in practice, episodes of diarrhea or stomach pain often led them to take whatever antibiotic was on hand because traveling to a clinic or paying for a consultation was not feasible. Their behaviors were shaped by the same structural conditions driving water insecurity: limited healthcare access, economic constraints, and reliance on informal providers. Earlier studies have noted similar tensions in the Philippines (Singer et al 2016), but the present findings extend this by showing how WASH-related vulnerabilities recurrent waterborne illnesses, unsafe drinking-water sources, and frequent gastrointestinal infections create repeated triggers for self-medication, normalizing partial adherence, and the sharing of antibiotics. These dynamics indicate that improving antibiotic stewardship requires more than awareness campaigns; it must involve expanding affordable diagnostics, strengthening prescription enforcement, and equipping barangay health workers to address the intertwined WASH and health system gaps influencing antibiotic use.

Cultural health practices and traditional medicine. Cultural health practices and traditional medicine shaped how residents managed illness, with snakeweed, five-leaf chaste tree, and peperomia, commonly used for fever, cough, and gastrointestinal discomfort. Reliance on these remedies increased during the COVID-19 pandemic amid fears of injections and limited trust in biomedical care. While previous studies highlight the role of herbal treatments in everyday self-care, the present findings show how these practices intersect with ongoing WASH challenges: frequent waterborne illnesses and inconsistent access to safe drinking water lead residents to first turn to familiar remedies before seeking formal treatment. Rather than viewing this pattern as a barrier, it presents an opportunity for traditional medicine to serve as a culturally grounded pathway for introducing AMR awareness and One Health concepts, linking familiar healing practices with broader messages about safe water, infection prevention, and appropriate care-seeking. In this way, indigenous knowledge becomes a valuable complementary resource for community engagement, not something to be replaced.

Taken together, the findings point to three interconnected areas for intervention: strengthening WASH infrastructure to ensure reliable access to safe drinking water and reduce repeated illness-driven antibiotic use; expanding environmental monitoring of lakes, pipelines, and household water sources to track microbial contamination and potential resistance reservoirs; and tightening antibiotic regulation and access, including affordable diagnostics and consistent prescription-only dispensing supported by capacitated barangay health workers. Advancing these three lines of action in parallel can address the structural, environmental, and behavioral drivers of AMR identified in this

community, aligning local realities with broader One Health priorities. These insights should, however, be interpreted alongside study limitations, including a modest sample size, reliance on self-reported practices, and data collection during a single season, which may not capture year-round fluctuations in water quality and illness patterns.

Conclusions. This study demonstrates how AMR risks in the Lakewood communities arise through the combined effects of environmental exposure, everyday health behaviors, and constrained access to healthcare. Contaminated water sources and the community's reliance on lake-derived food systems create overlapping exposure pathways, as households use the same water for drinking, washing, and occasional fish consumption, mechanisms supported both by local accounts and previous evidence on aquatic contamination. Traditional remedies such as snakeweed, five-leaf chaste tree, and peperomia often serve as first-line responses to recurrent gastrointestinal symptoms, which can delay clinical consultation and lead to antibiotic use only once symptoms intensify, increasing the likelihood of incomplete courses or inappropriate choices. Limited medical infrastructure, long travel distances, intermittent clinic hours, and out-of-pocket costs further reinforce self-medication, as participants described relying on leftover antibiotics or informal sources when professional care was inaccessible. Viewed together, these dynamics illustrate a concrete One Health pattern: environmental conditions shape illness episodes; illness episodes drive behavioral responses; and constrained healthcare access influences how antibiotics are used, producing interlocking pressures that sustain AMR vulnerabilities. A key contribution of this study is showing how these three domains, environmental quality, household decision-making, and structural access barriers, interact in rural settings where lake ecosystems and daily subsistence are tightly linked.

However, the qualitative design, limited number of households, and reliance on self-reported practices restrict the generalizability of these findings, and the study was unable to collect microbiological water or fish samples to directly test contamination pathways. Future work should integrate community narratives with microbiological sampling and seasonal monitoring to more precisely map how environmental exposure and everyday practices jointly shape AMR risks across the year.

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Conflict of interest. The authors declare that there is no conflict of interest.

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