

CASE REPORT



COVID-19 exposes weaknesses in public health in the Peruvian Amazon and highlights opportunities for a One Health approach

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Abstract

The Amazon is home to important wildlife and a biodiversity hotspot of global importance. The ancestral knowledge kept by Indigenous communities about its fauna and flora contributes further to its irreplaceable value. The Peruvian Amazon was heavily struck by the COVID-19 epidemic with a cumulative incidence of 725, a mortality rate of 34 per 100,000 inhabitants, and a case fatality rate of 4.6% by the end of July 2020. In this work, we review scientific literature and media to trace the events that happened at the beginning of the COVID-19 epidemic in the Peruvian Amazon. Results are synthesized in three observations: (1) the evolution of the COVID-19 epidemic within the Peruvian Amazon and the response of the Peruvian health care system, (2) Confusing information about Ivermectin use for COVID-19 treatment and prevalent self-medication (3) The response of the traditional Indigenous health care system to the COVID-19 epidemic. These three observations are interdependent. There is an unexploited potential for integrative approaches linking traditional medical practices (TMP) and biomedical approaches and they may benefit from the interactions that occur between them. Synergies can also be explored between the human and animal health care sector, especially in terms of the use and stewardship of medicines. We conclude that there is a benefit of the One Health approach in the region, which can go through the common ambition to improve the integrated health of people, animals and ecosystems, facilitate the enhancement of equity and inclusion while improving access to health services and conserving biodiversity.

One Health impact statement

The Amazon region is home to wildlife flora and fauna and indigenous Amazon communities. The case presented in this work shows that an existing grassroots initiative has been reducing case fatality rates tenfold during the COVID-19 epidemic, while acting in respect towards nature and the environment, and using its resources. This is in stark contrast to the uncontrolled, ineffective self-medication with ivermectin in that same period, which may endanger the biodiversity hotspot through metabolic residues. While the current example seems to illustrate community resilience due to government negligence, it also shows the vastly unexplored potential of integrating biomedical and traditional indigenous knowledge in a solidaric and co-creative framework such as One Health.

Keywords: Peruvian Amazon, ivermectin, traditional medical practices (TMP), One Health, COVID-19, biodiversity

Introduction

The Amazon region is a biodiversity hotspot of global importance (IUCN, 2021). It is distributed among the Pan-Amazonian region which encompasses the countries of Brazil, Peru, Bolivia, Colombia, Venezuela, Guyana, Suriname, French Guiana and Ecuador, covering a total area of 6 million km² and it is home to Indigenous

Amazon people (Sousa *et al.*, 2022). The Peruvian Amazon is one of the three natural regions of Peru and it is located in northeast of the country, characterized by its richness in vegetation, rivers, rainfall and low population density (Hernández-Vásquez *et al.*, 2022). A Census in 2017 detailed that 212,823 Peruvians self-identified as Amazonian Indigenous of which 156,486 (73.5%) lived

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in rural and 56,337 (26.5%) in urban areas. Only 77,510 (36.4%) learned Spanish in their childhood – the national language of Peru (Instituto Nacional de Estadística e Informática (INEI), 2017). Access to healthcare services for the Amazonian Indigenous communities living in rural areas is obstructed by geographical dispersion, poor communication roads (Soto-Cabezas *et al.*, 2022), low availability and high cost of transportation and socio-cultural inequities (Hernández-Vásquez *et al.*, 2022). Consequently, most communities are only accessible by boat such as canoes and traditional boats (Instituto Nacional de Estadística e Informática (INEI), 2017) and transportation of patients is prohibitively expensive (Hernández-Vásquez *et al.*, 2022).

Rural Amazon communities' concept and practices of health focus on the well-being of their communities and rely on traditional medicine, including the use of medicinal plants, special food preparations and diet restrictions and rituals with the participation of close family members and spiritual healers (Carrillo *et al.*, 2022). The people of the Amazon region have a history of being marginalized, especially in regard to access to primary health care (Gianella *et al.*, 2019; Ramírez *et al.*, 2020; Vázquez-Rowe and Gandolfi, 2020; Sousa *et al.*, 2022). Socio-cultural barriers are related to the lack of inclusion of their cultural beliefs and traditional medicine as these practices are not integrated into the Peruvian health system (Brierley *et al.*, 2014).

By July 31, 2020, the Peruvian Amazon region presented a cumulative COVID-19 incidence of 725 (110,068/15,192,638), a mortality rate of 34 per 100,000 inhabitants (5102/15,192,638), and a case fatality rate of 4.6% (19,217/414,735) (Instituto Nacional de Estadística e Informática (INEI), 2009; Ministerio de Salud-DGE, 2022). Peru was among the six countries most impacted by COVID-19 worldwide (World Health Organization, 2022) with 655 deaths per 100,000 inhabitants and a 5.2% case-fatality rate as of September 18, 2022 (Johns Hopkins Coronavirus Resource Center, 2022).

During the COVID-19 pandemic, Ivermectin was recommended without scientific evidence (Lescano and Pinto, 2020) using media like YouTube channels, TV interviews (Molento, 2020) and newspapers (Alvarez-Risco *et al.*, 2020) which led people to easily opt to self-medicate as Ivermectin was sold without prescription in some drugstores and black markets (Mega, 2020). Ivermectin is a broad-spectrum antiparasitic used worldwide in both human and animal health. In humans, it is commonly used as a treatment for strongyloidiasis, onchocerciasis and filariasis, generally as part of mass drug administration strategies in African settings (Speare and Durrheim, 2004). In veterinary medicine, it is commonly used for the control of diverse endo- and ectoparasites in both livestock and companion animals (Crump and Ōmura, 2011). The therapeutic index of ivermectin is relatively high and consequently, only heavy overdosing causes neurological side effects in both humans (Cook, 1995) and animals (Shoop *et al.*, 1995). However, non-target organisms such as aquatic animals, in contrast, may be very sensitive to ivermectin toxicity, and residues of the active compound itself or its metabolic derivatives can seriously harm ecological systems where overuse occurs (Wall and Strong, 1987). Ivermectin had already a good reputation for the control and treatment of parasitic infections in humans (Speare and Durrheim, 2004) and animals (Crump and Ōmura, 2011).

The present work describes the events that occurred during the first COVID-19 wave in the Peruvian Amazon and reflects on the potential of the One Health (OH) approach could bring to the region.

Methods

We reviewed scientific literature and the press to narrate the events that happened at the beginning of the COVID-19 epidemic in the Peruvian Amazon and searched for reports and scientific publications about ivermectin off-label use. The findings were structured into distinct themes based on grounded theory, a

systematic methodology frequently used in qualitative research. In essence, the method posits that as researchers review the data, ideas or concepts become apparent to them. These ideas/concepts are said to 'emerge' from the data. In the present process, scientific and media publications were interpreted collectively by the researchers as they became available, and the emerging themes were further investigated to clarify ambiguities.

Results

The case study is structured along three major themes of observation: (1) the evolution of the COVID-19 epidemic within the Peruvian Amazon and the response of the Peruvian health care system, (2) Confusing information about Ivermectin use for COVID-19 treatment and prevalent self-medication, and (3) the response of the traditional Indigenous health care system to the COVID-19 epidemic.

THE EVOLUTION OF THE COVID-19 EPIDEMIC WITHIN THE PERUVIAN AMAZON AND THE RESPONSE OF THE PERUVIAN HEALTH CARE SYSTEM

A lockdown was implemented throughout Peru on March 16, 2020, ten days after the first COVID-19 case was reported (Lainez *et al.*, 2021). Within 5 days of the first case, daily oxygen demand in hospitals exceeded supplies. Throughout the country, there was only a very limited diagnostic test capacity available, which combined with the lack of drugs (Fraser, 2020), medical oxygen (Ramírez *et al.*, 2020) and personal protective equipment (PPE) for medical staff, made it challenging to contain the spread of the epidemic (García *et al.*, 2020).

After the publication of in vitro efficacy to inhibit SARS-CoV-2 replication in cell cultures (Caly *et al.*, 2020), in May the Ministry of Health of Peru (MINSa) approved the use of ivermectin for the treatment of mild, moderate and severe COVID-19 cases with dosing at 1 drop (200 µg) per kilogram of body weight for two days (Ministerio de Salud del Perú, 2020). In this "Resolución Ministerial N270-2020-MINSa", ivermectin was placed on the list of strategic drugs, and its supply was ensured for the treatment of mild cases in primary health care establishments. Once ivermectin treatment was widely available, routine clinical use started rapidly and included both inpatient and outpatient treatments (Chamie-Quintero *et al.*, 2021). The MINSa also officially supported its use for both pre- and post-exposure prophylaxis (Instituto Nacional de Salud del Perú, 2021). Nevertheless, primary health care services were not able to attend to the exponentially growing demand from people with severe clinical SARS-CoV-2 infections (Schwalb and Seas, 2021). This serious national situation was also exacerbated by the high incidence of infections among health care workers (Chafloque-Vásquez *et al.*, 2020; Alvarez-Antonio *et al.*, 2021).

In the Peruvian Amazon, the situation was further aggravated by limited access to health care services, largely due to logistic constraints, as all supplies must be delivered by boat or airplane (roads are often absent) and the services rely on a very small number of medical doctors and health professionals with a lack of critical supplies. The first COVID-19 case within the region was detected in Iquitos, the capital of the Loreto, and the area with the largest number of Peruvian Amazon Indigenous communities. In July 2020, a serosurvey in Iquitos found an adjusted seroprevalence of anti-SARS-CoV-2 IgG and IgM antibodies of 70% (Alvarez-Antonio *et al.*, 2021). Loreto had one of the highest mortality rates in the country (Ramírez *et al.*, 2020), with 50 deaths per 100,000 inhabitants (Ministerio de Salud-DGE, 2020).

CONFUSING INFORMATION ABOUT IVERMECTIN USE FOR COVID-19 TREATMENT AND PREVALENT SELF-MEDICATION

It is challenging to distinguish "maladroit" communication from an "infodemic", which implies that some players deliberately

manipulate the information to cause confusion, contradiction and segregation in society. One could argue that the lack of scientific evidence in the use of ivermectin set the scene for infodemics to later cause self-medication (Lescano and Pinto, 2020). The term “infodemic” is the combination of the words “information” and “epidemic” and refers to the excess of information which increases exponentially in a very short time, making it increasingly difficult for the public to access reliable information (García-Saisó *et al.*, 2021). In the context of COVID-19, scientific information has been intensely manipulated or mixed with false recommendations, rumors, stigma and/or conspiracy theories, leading to a twinned viral and informational epidemic (Islam *et al.*, 2020). The combination of rapidly increasing case numbers, an already fragile health system, and incomplete information on the effectiveness of ivermectin (when the observations of Caly *et al.* (2020) were not confirmed in clinical settings) in public and social media (Schwalb and Seas, 2021), encouraged self-medication and widespread use of both prescribed and non-prescribed drugs. In Peru self-medication, i.e. the practice of selecting and using medicines to treat self-recognized symptoms and health-related problems (World Health Organization, 1998), is a frequent practice associated with both demographic (social, cultural and personal norms) and health system factors (limited access to medicines and other healthcare services) (Urrunaga-Pastor *et al.*, 2019), and often strongly encouraged by the press and media (Lainez *et al.*, 2021). A study about the proportion of citizens unable to recognize fake news during the COVID-19 epidemic found that this proportion was largest in Peru among populations from Argentina, Brazil, Chile, Colombia and Mexico and that Peruvians had an indiscriminatory great confidence in the content of social media news (Nieves-Cuervo *et al.*, 2021). Another study observed that a better education level was associated with having correct ideas about COVID-19 and that the scarce information given by Peruvian authorities about the management of COVID-19 resulted in the lowest level of knowledge about how to manage new diseases (Mejia *et al.*, 2022). In this context, some physicians encouraged the use of drugs such as ivermectin to prevent COVID-19 cases (Maguiña-Vargas and Palacios-Celi, 2020), and some magazines even presented front-page articles praising the veterinary formulation of ivermectin as the cure for COVID-19 infections (Alvarez-Risco *et al.*, 2020). Ivermectin was initially approved as an official COVID-19 treatment by the Ministry of Health (MINSA) on May 8, 2020, and the recommendation was withdrawn on September 7, 2020 because of the lack of evidence for its effectiveness (Quispe-Cañari *et al.*, 2021). However, during those months, there were authorities and organizations supporting the use of ivermectin, as on May 10, 2020, the Peruvian College of Veterinary Doctors expressed its support for MINSA recommendations about the inclusion of ivermectin in the treatment of human COVID-19 cases, to later request the authorization that the veterinary formulation could be used in the treatment of those cases (Lescano and Pinto, 2020). In the same way, some academics and well-known physicians published letters about its effectiveness (Portmann-Baracco *et al.*, 2020), and a veterinarian promoted its use, while simultaneously promoting a COVID-vaccine that his own company produces and discredited internationally recognized vaccines (Diario El Comercio, 2021). Other misinformation recommended the use of hydroxychloroquine, azithromycin (Quispe-Cañari *et al.*, 2021) and warfarin to prevent COVID-19 (Martinez-Rivera and Taype-Rondan, 2020; Acuña-Chavez *et al.*, 2021). Consequently, the uncertainty about effective means to mitigate the effects of COVID-19 grew in a state in which the health system had collapsed.

The demand for ivermectin rapidly increased throughout Peru. The limited availability of ivermectin preparations for human use on the market led to a dramatic increase in prices with large differences between private and public pharmacies (Tenorio-Mucha *et al.*, 2020; Schwalb and Seas, 2021). This led to many people using preparations intended for veterinary use, including parenteral formulations, as an alternative to scarce human doses. The demand for all formulations of ivermectin still increased and prices for the

drug were extremely high, leading to the emergence of an illegal market for veterinary ivermectin (Mega, 2020). Subsequently, on May 26, 2020, the General Directorate of Medicines, Supplies and Drugs (DIGEMID) issued a statement that specifically addressed the rising concern about the use of veterinary ivermectin formulations for COVID-19 treatment in humans (Ministerio de Salud-DIGEMID, 2020). This alert explicitly stated that ivermectin can only be prescribed by authorized medical personnel under supervision and monitoring for any adverse drug reactions.

There are no official reports of the total quantity of ivermectin imported or delivered (or which product(s) were delivered), nor any estimates on the number of people who self-medicated with veterinary ivermectin formulation during this period – which we will further define as “off-label use”. To estimate the extent of this “off-label” use, we compared the quantities of ivermectin imported into Peru for animal health purposes from 2019 to 2021 (Veritrade, 2022): in 2019—903 kg; in 2020—3738 kg; and in 2021—1096 kg. We infer that in 2020, an excess of approximately 2,800 kg of veterinary ivermectin was imported, and likely offered off-label to people. With an estimated 14mg per treatment (for 70kg body weight), this would correspond to approximately 200 million treatments within a population of 32 million. Chamie-Quintero *et al.* (2021) describe some cases of routine clinical use of ivermectin based on the written press (Table 1).

We also examined a peer-reviewed case report on the *subcutaneous* application of veterinary ivermectin as COVID-19 treatment: in June 2020 in Iquitos, Loreto, Peruvian Amazon, two persons presented with necrotic skin ulcers after having suffered from moderate symptoms of a SARS-CoV-2 infection. It was determined that these ulcers occurred 5–8 days after subcutaneous injection of veterinary ivermectin as treatment (Ramal-Asayag *et al.*, 2020); the report did not specify the cause of the ulcerations.

THE RESPONSE OF THE TRADITIONAL INDIGENOUS HEALTH CARE SYSTEM TO THE COVID-19 EPIDEMIC

Due to the large excess mortality rates in the Peruvian Amazon, a grassroots initiative called “Comando Matico” emerged. This initiative was formed by volunteers who revived traditional knowledge and practices by using medicinal plants and therapies (conventional and traditional medicine) which were used by ancestral female healers to care for patients who were unable to access health services in remote communities (Delgado and Herrera, 2021; Montag *et al.*, 2021). They also interacted with medical doctors to adapt their treatments to the needs of Indigenous communities (Balvín Bellido, 2021; Montag *et al.*, 2021). Despite these important efforts to contain the pandemic and maintain traditional knowledge, some leading traditional healers died from COVID-19 infections. Moreover, Indigenous populations lost their trust in the modern health care system and were increasingly reluctant to visit hospitals (Delgado and Herrera, 2021).

Discussion

These three observations are interdependent. They illustrate that the fragility of the health care system may lead to people seeking their own path to health, at the risk of being misled at various crossroads. The present work highlights the importance of scientific grounding when evaluating drugs for public recommendations as pointed by Lescano and Pinto (2020). Furthermore, the WHO has published principles for effective communication as a tool to respond to worldwide infodemics (World Health Organization, 2023). Interestingly, a number of principles were violated during the COVID-19 pandemic in Peru: (I) Accessible communication: vulnerable populations like Indigenous, rural and village people have poor access to digital information channels and press and were therefore not reached by the MINSA statements. (II) Actionable, (IV) relevant and (VI) understandable recommendations: recommendations were addressed to medically trained experts and did not consider the state of knowledge and scope of action

Table 1. An overview of newspapers describing the veterinary ivermectin off-label use in the Peruvian Amazon.

	Year 2020	Stakeholder involved		Amount donated	Sources (PRESS)	Cited by
		donation	reception			
Loreto	May-11	veterinarian	local medical college	6000 doses in 2 weeks	Panamericana televisión (2020)	(Chamie-Quintero <i>et al.</i> , 2021)
	June 18	medical doctor	General public	15,000 doses	Diario Ahora (2020)	
Ucayali	April	Political parties, government authorities	local authorities and health centers	Using radio stations promoted the application of veterinary ivermectin to 5000 people aprox.	El Pais (2020)	(Chamie-Quintero <i>et al.</i> , 2021)
Nauta, Loreto region	June 19	A mayor, evangelical group	General public	Delivering 500 doses plus a donation of 1000 additional supplies	El Comercio, 2020	(Fowks, 2020)

of ordinary citizens and people with specific risks; (III) Credibility: The information could have been more elaborated in addressing errors and acknowledging uncertainty, and there was a lack of coordination with the other partners in the health care system.

Our example also illustrates that there is an unexploited potential for integrative approaches linking Indigenous medical practices and the biomedical approach to form a more resilient health care system. Traditional medical practices (TMP) rely on locally available resources, and have the potential to absorb much of the acute needs for health care (Pesantes and Camila, 2020). While reports on the efficiency and effectiveness of traditional medicine are limited, Caretas (2020) and the Centro Amazónico de Antropología y Aplicación Práctica (CAAAP) (2020) reported that the grassroots initiative “Comando Matico” had treated people in Amazon communities during the first wave of COVID-19 resulting in a roughly tenfold lower case fatality rate (0.37% = 2 deaths in 538 treated people) compared to 4.6% at national level (Ministerio de Salud-DGE, 2020). In contrast, this initiative may not be able to deal with the more severe conditions as were seen in moderate and severe COVID-19 cases. By shifting the first response to TMP, and focusing biomedical health care on those severe cases, where TMP may reach its limits, valuable resources can be liberated for the more resource-intensive biomedical health care. Both, traditional and modern medical practices may benefit from their interaction in the learning process of sharing and receiving knowledge and adequate this knowledge to their medical practices and to the need of the respective communities they are treating. At the same time, Indigenous health practitioners may benefit from these interactions, e.g. through advice about the use of PPE and safer biosecurity practices. However, to transit patients seamlessly from one caretaker to the next, they must be linked in an integrated framework. For this integration it is critical that all actors value each other’s worldview, skills, practices and impact (Hitziger *et al.*, 2017; Riley *et al.*, 2021; Berger-Gonzalez *et al.*, 2022).

Secondly, synergies could be generated between the human and the animal health care sector. As the off-label use of ivermectin against COVID-19 demonstrates dramatically, a shortage of supply in one sector may be filled, deliberately or not, by the other. As an example, this has been effectively implemented for the cross-domain treatment of *Strongyloides stercoralis* (Barrett *et al.*, 2016; Zeitler *et al.*, 2018). However, if such synergy is not foreseen in drug regulations, this practice may be pushed to “grey markets” – such as the off-label self-medication with ivermectin – and thus not benefit from professional guidance. There is a toxicity risk with every patient that uses ivermectin without medical advice (in oral and parenteral treatment). As a consequence, the 2.8 tons of ivermectin (and its metabolites) presumably administered during the COVID-19 epidemic across Peru may well have detrimental

effects on aquatic ecosystems and soil fauna in a global biodiversity hotspot like Amazonia. Indeed, the concentration of metabolites of many drugs in water and soil has risen during the pandemic (Morales-Paredes *et al.*, 2022). This is known to impact the life cycles of invertebrate fauna like dung beetles, earthworms, springtails and enchytraeids, and affect vertebrates that are susceptible to ivermectin like turtles (Teare and Bush, 1983; Mesa *et al.*, 2020; de Souza and Guimarães, 2022). These organisms fulfill key roles in food webs, and thus the second-round effects of drugs constitute a serious risk to the health and well-being of humans, animals and ecosystems.

Interestingly, we did not find published data or case reports regarding the off-label use of corticosteroids (largely dexamethasone), which were recommended by the WHO against severe symptoms of SARS-CoV-2 infections (World Health Organization, 2020) in the Peruvian context. The Peruvian government recommended the use of steroids to alleviate COVID-19 symptoms but simultaneously pointed out the risks of self-medication (Ministerio de Salud del Perú, 2021).

Independently of the pandemic, the promotion of self-medication with potent drugs is problematic and there is a need for awareness and sensitization on the consequences that self-medication brings (Quispe-Cañari *et al.*, 2021). The same applies to medication without medical guidance in animal health. Golovliov *et al.* (2021) found that 35% (142/408) of clients of veterinary services in Lima (Peru’s capital), gave medicines to their companion animals without first visiting a veterinary clinic. The most frequent drugs that owners gave to their pets were analgesics/anti-inflammatories (46/142), followed by antiparasitic drugs (33/142). These drugs do not require a veterinary prescription as they can be bought in pet shops, but the same risks result from self-medication as owners may not have adequate knowledge for disease diagnosis and treatment. The study also found that 63% (255/408) of the respondents did not know or hear about “antimicrobial resistance” (AMR) (Golovliov *et al.*, 2021). This result is alarming in the context of the observed frequency of self-medication with potent drugs in humans and animals. It emphasizes the importance of sensitization and awareness campaigns provided by the government and academic institutions and organizations about the risks of medication without medical guidance, antimicrobial resistance and environmental toxicity.

The integration of TMP, the human and animal health sectors, and environmental sustainability programs, requires an integrated approach like One Health (OH). The approach has been described as building on systems thinking, intersectoral planning, transdisciplinarity and infrastructure to facilitate sharing, learning and decentralized, adaptive governance (Rüegg *et al.*, 2017).

Systems thinking and transdisciplinarity allow the combination of knowledge with different epistemic paradigms from TMP, biomedicine and life science. Transdisciplinarity also facilitates the mobilization of tacit knowledge specific to the remote sites at which the Indigenous Amazonian communities live, to identify the practical and relevant synergies in health service provision. These are clearly distinct from those in urban settings and include difficulties in disseminating relevant information appropriately (Soto-Cabezas *et al.*, 2022). The participation of citizens in decisions fosters inclusion, stewardship and helps to reduce the structural discrimination of Indigenous Peoples that has been highlighted by the COVID-19 pandemic (Mallard *et al.*, 2021; Montag *et al.*, 2021; Solis and Nunn, 2021). Indigenous Amazonian communities are well organized, have a sense of community as a family, respect their elderly and live their tradition based on the respect of biodiversity and the environment. The valuation of TMP and its integration into health policies would thus directly contribute to the ambitions of the One Health High-Level Expert Panel and the Convention on Biological Diversity to simultaneously improve the health of people, animals and ecosystems (Convention on Biological Diversity, 2017; Adisasmito *et al.*, 2022). Building legislation that foresees sharing of resources and information across the sectors and allowing for decentralized adaptive governance which is informed by feedback from the changing environment, would allow exploiting the synergies between the human and animal health sector mentioned above. It would be embedded in the local socio-ecological system, facilitate rapid, targeted deployment of the scarce resources available under difficult logistic conditions and contribute to resilience in situations of crisis. Essentially, an OH approach to emerging health threats could encode solidarity and cultural humility in a legal framework that would set the scene for better health for more living beings in the future.

From a central government perspective, an OH approach presents new opportunities and challenges. As it implies an explicit delegation of control to peripheral governance structures, it bears the promise of being more inclusive with the challenge of creating accountability. The need to evaluate and demonstrate the relevance of local and national efforts to promote OH is thus central and must include aspects of equity, efficiency and improved health outcomes in people, animals and ecosystems as well as the processes of knowledge integration (Rüegg *et al.*, 2018). The decentralized governance also attributes new roles to the actors in the health system. As explored by Hitziger *et al.* (2018) the potential synergies generated by OH approaches are often hampered by limitations in both health governance structures and policy implementation. In an OH approach, central governments would have more responsibility in identifying, endorsing and valuing emerging local initiatives like the “Comando Matico”. These must be complemented and integrated with basic services like primary health care, and for informed decision making the local governance structures should be supplied with data correcting for the currently under investigated populations (Mallard *et al.*, 2021; Solis and Nunn, 2021). In return, cross-sectoral planning across different scales from local to national governance would prevent emerging, self-organizing initiatives such as the “Comando Matico” are used to justify the neglected or slow response of state institutions and the government (Delgado and Herrera, 2021).

Finally, because Indigenous Amazonian communities live in nine countries of the Amazon under similar socio-economic conditions, the COVID-19 pandemic, AMR and other emerging health threats can be viewed as transboundary problems for which national and local policies can be coordinated across borders and governance levels.

CONFLICT OF INTEREST

The authors have declared that no competing interests exist.

ETHICS STATEMENT

All relevant guidelines were followed.

DISCLAIMER

The views expressed in this article reflect the result of research conducted by the author and do not necessarily reflect the position of any department or institution nor the Peruvian Government.

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AUTHOR CONTRIBUTIONS STATEMENT

All authors approved the submitted version. VO and SR designed the original manuscript. Tables were designed by VO. RE, SD, AL and SR finalized the review.

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