One Health 2

A global analysis of One Health Networks and the proliferation of One Health collaborations

Athman Mwatondo, Afifah Rahman-Shepherd*, Lara Hollmann, Scott Chiossi, Josphat Maina, Karishma Krishna Kurup, Osama Ahmed Hassan, Beatrice Coates, Mishal Khan, Julia Spencer, Nyamai Mutono, Samuel M Thumbi, Mathew Muturi, Mumbua Mutunga, Liã Bárbara Arruda, Melika Akhbari, Dena Ettehad, Francine Ntoumi, Terence P Scott, Louis H Nel, Johanne Ellis-Iversen, Ute Wolff Sönksen, Diana Onyango, Zuleka Ismail, Kebadu Simachew, David Wolking, Rudovick Kazwala, Zikankuba Sijali, Bernard Bett, David Heymann, Richard Kock, Alimuddin Zumla, Osman Dar*

There has been a renewed focus on threats to the human–animal–environment interface as a result of the COVID-19 pandemic, and investments in One Health collaborations are expected to increase. Efforts to monitor the development of One Health Networks (OHNs) are essential to avoid duplication or misalignment of investments. This Series paper shows the global distribution of existing OHNs and assesses their collective characteristics to identify potential deficits in the ways OHNs have formed and to help increase the effectiveness of investments. We searched PubMed, Google, Google Scholar, and relevant conference websites for potential OHNs and identified 184 worldwide for further analysis. We developed four case studies to show important findings from our research and exemplify best practices in One Health operationalisation. Our findings show that, although more OHNs were formed in the past 10 years than in the preceding decade, investment in OHNs has not been equitably distributed; more OHNs are formed and headquartered in Europe than in any other region, and emerging infections and novel pathogens were the priority focus area for most OHNs, with fewer OHNs focusing on other important hazards and pressing threats to health security. We found substantial deficits in the OHNs collaboration model regarding the diversity of stakeholder and sector representation, which we argue impedes effective and equitable OHN formation and contributes to other imbalances in OHN distribution and priorities. These findings are supported by previous evidence that shows the skewed investment in One Health thus far. The increased attention to One Health after the COVID-19 pandemic is an opportunity to focus efforts and resources to areas that need them most. Analyses, such as this Series paper, should be used to establish databases and repositories of OHNs worldwide. Increased attention should then be given to understanding existing resource allocation and distribution patterns, establish more egalitarian networks that encompass the breadth of One Health issues, and serve communities most affected by emerging, re-emerging, or endemic threats at the human–animal–environment interface.

Published **Online** January 19, 2023 https://doi.org/10.1016/S0140-6736(22)01596-3

See **Online/Comment** https://doi.org/10.1016/S0140-6736(23)00086-7

This is the Second in a **Series** of four papers about **One Health**. All papers in the Series are available at thelancet.com/series/one-health-and-global-health-security.

*Joint first authors

Zoonotic Disease Unit, Ministry of Health, Nairobi, Kenya (A Mwatondo MD, J Maina MD); **Zoonotic Disease Unit, Ministry of Agriculture, Livestock, and Fisheries, Nairobi, Kenya** (M Muturi DVM); **Global Health Programme** (O Dar MBBS MSc), **Royal Institute of International Affairs, London, UK** (A Mwatondo, A Rahman-Shepherd MSc, L Hollmann MSc, S Chiossi MSc, K K Kurup MD, O A Hassan PhD, B Coates MSc, M Khan PhD); **International Livestock Research Institute, Nairobi, Kenya** (A Mwatondo, J Maina, M Muturi, B Bett PhD); **Department of Infectious Disease Epidemiology** (Prof D Heymann MD), **London School of Hygiene & Tropical Medicine, London, UK** (A Rahman-Shepherd, M Khan, J Spencer MSc); **Department of Community Health Sciences and Department of Pathology, Aga Khan University, Karachi, Pakistan** (M Khan); **Paul G Allen School for Global Animal Health, Washington State University, Pullman, WA, USA** (N Mutono MSc, S M Thumbi PhD); **Center for Epidemiological Modelling and Analysis** (S M Thumbi, N Mutono) **and Institute of Tropical and Infectious**

Introduction

Since the term One Health emerged in the early 2000s, efforts to operationalise a One Health approach at global, regional, and national levels have increased.[1,2] Governments, academic institutions, and non-government organisations have implemented a One Health ethos and formalised these commitments to cross-sectoral and intersectoral collaborations through One Health platforms, networks, steering committees, and task forces.[1,3]

In 2010, the alliance between the Food and Agricultural Organization of the UN, the World Organisation for Animal Health, and WHO, known as the Tripartite, outlined the need for institutional cooperation at the human–animal–environment interface. Although the collaboration of the Tripartite was the start of an uptake of the One Health framework, their focus has typically been managing zoonotic diseases and a small set of high-impact threats that have the potential to trigger global or regional health security crises.[4] This narrowly defined agenda, which included institutional mandates in human health, domesticated animal health, food systems, and agriculture, did not holistically advocate an inclusive and comprehensive approach to complex One Health issues. For example, they did not engage social scientists, anthropologists, or Indigenous communities on issues of biodiversity loss, environmental degradation, or natural resource depletion.

The COVID-19 pandemic has highlighted the interconnectedness of human health, animal health, the state of the environment, and the negative effects of underestimating threats at this interface.[5–7] As WHO Director-General Dr Tedros Adhanom Ghebreyesus stated on Jan 18, 2021, the pandemic has shown that "[One Health] must become more than a concept, it must be translated into systems that keep people safer".[8] Efforts to achieve this goal have begun. In May, 2020, the Tripartite and the UN Environment Programme (UNEP) launched the One Health High-Level Expert Panel (OHHLEP).[9] Although many definitions of One Health have been proposed and used in the past, the definition provided by OHHLEP in December, 2021, of One Health establishes common language and understanding. OHHLEP defines One Health as an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals, and ecosystems and requires mobilising multiple sectors, disciplines, and communities to

Diseases (M Mutunga BSc) **University of Nairobi, Nairobi, Kenya; Institute of Immunology and Infection Research, University of Edinburgh, Edinburgh, UK** (S M Thumbi)**; Department of Infection** (Prof A Zumla PhD) **and Centre for Clinical Microbiology, Division of Infection and Immunity, University College London, London, UK** (L B Arruda PhD)**; Clinical Academic Training Office, University of Cambridge, Cambridge, UK** (M Akhbari MBBS)**; Academic Foundation Programme, Faculty of Medicine, Imperial College London, Imperial College Healthcare NHS Trust, London, UK** (D Ettehad MD)**; Fondation Congolaise pour la Recherche Médicale, Brazzaville, Democratic Republic of the Congo** (F Ntoumi PhD)**; Institute for Tropical Medicine, University of Tübingen, Tübingen, Germany** (F Ntoumi)**; Global Alliance for Rabies Control, Pretoria, South Africa** (T P Scott PhD)**; Department of Biochemistry, Genetics, and Microbiology, University of Pretoria, Pretoria, South Africa** (L H Nel PhD)**; The Danish Veterinary and Food Administration, Glostrup, Denmark** (J Ellis-Iversen PhD)**; National Centre for Antimicrobials and Infection Control, Statens Serum Institut, Copenhagen, Denmark** (U W Sönksen PhD)**; The One Health for Humans, Environment, Animals and Livelihoods Project, Addis Ababa, Ethiopia** (D Onyango MSc, Z Ismail MSc, K Simachew MSc)**; One Health Institute, University of California, Davis, CA, USA** (D Wolking MSc)**; Department of Veterinary Medicine and Public Health, Sokoine University of Agriculture, Morogoro, Tanzania** (R Kazwala PhD, Z Sijali DVM)**; Royal Veterinary College, University of London, London, UK** (Prof R Kock DVM PhD)**; National Institute for Health and Care Research Biomedical Research Centre, University College London Hospitals NHS Foundation Trust, London, UK** (Prof A Zumla)**; Global Operations, UK Health Security Agency, London, UK** (O Dar)**; Saw Swee Hock School of**

Key messages

- A global analysis of One Health Networks (OHNs) revealed deficits in geographical distribution and partnership structures, with potential effects on the effectiveness and sustainability of One Health efforts to address urgent threats to global health.
- There are more OHNs headquartered or operational in Europe than in any other region worldwide; the most reported focus areas of OHNs are emerging infections with pandemic potential and novel pathogens.
- There are still self-identified OHNs that have little involvement with environment or ecosystems stakeholders, which restricts the extent to which a multisectoral One Health approach is done in reality; OHNs are engaging fewer community stakeholders in the design and agenda-setting phases of implementation than other types of stakeholders (eg, academic institutions and government bodies).
- The One Health movement and those involved should stop high-income hegemony and a global health framework that is based on colonial structures to establish more egalitarian networks that genuinely attempt to overcome One Health issues and help communities most affected by emerging and endemic threats.
- This and other similar analyses should be used as a baseline to establish databases and repositories of OHNs worldwide, help identify deficits in their mandates and activities, and improve directions of investment.

overcome threats to health and ecosystems.[10] Crucially, the definition highlights important environmental issues that One Health approaches should address: clean water, energy and air, safe and nutritious food, climate change, and sustainable development.[11] The Tripartite and UNEP formalised their collaboration as the new Quadripartite collaboration for One Health in March, 2022, enabling a global governance framework for close cooperation at the human, animal, plant, and ecosystem interface.[12]

Collaboration through a One Health approach

The One Health concept advocates for increased multisectoral, transdisciplinary, and community-oriented cooperation.[13–15] Establishing optimal health in all living systems requires overcoming traditional disciplinary and sectoral boundaries and removing hierarchies within and between countries. How One Health is operationalised, and the process of operationalisation, influences the nature and extent of cooperation between stakeholders on important issues.[16] The need for partnership is integral to this understanding of One Health, yet the question regarding what constitutes a good partnership in One Health has not been fully assessed.[16] Although literature on the technical competencies needed to implement a One Health approach is abundant, there is less literature about cultivating the values and attributes that encourage effective One Health cooperation and collaboration.[17,18] Working with the Quadripartite, OHHLEP has articulated these values as equity between sectors and disciplines; sociopolitical parity and inclusion; establishing a socio-ecological equilibrium; stewardship as a human responsibility; and transdisciplinarity with respect for different knowledge systems.[10]

The lack of dialogue on what constitutes an equitable and effective One Health partnership, and how to accurately evaluate partnership performance, is evident in some of the challenges for the One Health community and efforts to operationalise the approach. Khan and colleagues[1] were the first to quantitatively analyse One Health Networks (OHNs), recognising that the proliferation of OHNs can sometimes undermine cohesion and collaboration across organisations and programmes. They identified several negative consequences of poorly coordinated OHN growth, including specific deficits in the coverage of OHN activities, imbalances in stakeholder representation, unclear or missing accountability structures, and potential duplication of efforts. Understanding the current global distribution of OHNs and how they form and operate is crucial to addressing and guiding political and financial investments in One Health, particularly as the approach has received increased international support as a result of the COVID-19 pandemic.

In this Series paper, we provide a global identification and analysis of OHNs. There were three aims of this analysis: to show OHNs and support efforts to develop a worldwide repository of networks and initiatives; to highlight the areas of focus and alignment with global health security of OHNs; and to identify potential gaps in OHN formation from a needs-based and partnership-strengthening perspective that could contribute to effective investment and collaborations.

Identification and analysis of OHNs globally

As defined by Khan and colleagues,[1] an OHN is "an engagement (formal or informal) between two or more discrete organisations or entities, with representation from at least two of the three broadly categorised One Health sectors" (eg, animal health [domestic and wildlife], human health, and environment or ecosystem health). We used this broad conceptualisation to be intentionally inclusive for a few reasons. First, this Series paper is intended to be a database of various One Health collaborations and initiatives, providing a cross-sectional analysis rather than a measure of the extent to which they are One Health.[3,19,20] Second, we applied this broad conceptualisation as a search tool to identify the range of OHNs, not to establish new or separate One Health terminology, recognising that during the past 20 years numerous definitions have been used to define One Health and that this variation in definition is evident in the ways OHNs have been established and self-identify.

Finally, we used the globally endorsed OHHLEP definition of One Health for our analyses as it includes multiple sectors and disciplines, although there is no exact number or combination of sectors that qualify as a One Health approach.[10] To achieve our third objective of assessing how partnerships in One Health are structured, we applied the broad conceptualisation to the permanent, also known as founding, organisations of an OHN, rather than to all collaborators. The search strategy, eligibility criteria, and findings are described elsewhere (appendix pp 1–20).

Overview of current OHNs

The combined search strategy yielded 22 792 results, from which 19 063 duplicates were removed and 184 unique OHNs were included for further analysis (appendix pp 9–20). Of the 184 OHNs included, 137 (74%) stated that their OHN used a One Health approach, 14 (8%) used an EcoHealth approach, 3 (2%) used a Planetary Health approach, and 30 (16%) did not specify an approach. 64 (35%) were founded as projects or programmes and 22 (12%) were formed as subnetworks of existing OHNs. An example of an OHN classified as a subnetwork would be the Emerging Infectious Diseases: South East Asia Research Collaboration Hub,[21] which was formed by the Centers for Research in Emerging Infectious Diseases (CREID) Network as one of ten research centres. 143 (78%) of the 184 included OHNs are currently active, 33 (18%) are no longer active, and 8 (4%) did not provide information of their status. Of the 33 inactive networks, 28 (85%) are completed projects or programmes.

Since the early 2000s, there has been a substantial increase in the number of OHNs (appendix pp 21–23). 109 (59%) of included OHNs were formed between 2010 and 2019, although there is substantial year-by-year variation in newly formed OHNs. The highest number of OHNs was formed in 2014 and 2019, with 16 OHNs formed in each of these years. 2016 (15 OHNs), 2011 (13 OHNs), and 2020 (13 OHNs) also had high numbers of newly formed OHNs (appendix pp 21–23). Between 2020 and 2022, during the COVID-19 pandemic, 20 (11%) OHNs were formed. An example of an OHN established in this timeframe is the CREID, an OHN funded by the National Institute of Allergy and Infectious Diseases with ten research centres working worldwide to study and understand emerging pathogen transmission, to develop tools to improve detection of emerging pathogens and their vectors, and to enable rapid response for future outbreaks.[22] The fluctuation in OHN formation might be associated with the occurrence of epidemics, such as the Ebola virus epidemic (2014–16) or the Zika virus epidemic (2015), which were both declared public health emergencies of international concern.[23] Other international events or threat-related global initiatives could be considered to be triggering factors of increased OHN formation (eg, the beginning of the global action plan on antimicrobial resistance in 2015) or programmes with substantial funding that support the formation of new OHNs (eg, the EU-funded One Health European Joint Programme or the Joint Programme Initiative on Antimicrobial Resistance).[24–26]

79 (43%) of the 184 included OHNs are active in Europe, 78 (42%) in Africa, 71 (39%) in Asia, 47 (26%) in North America, 27 (15%) in South America, 18 (10%) in Oceania, and 3 (2%) in the Arctic (appendix pp 22–23). Overall, more OHNs were operationalised at a national level (73 of 184 [40%]) than at a regional level (54 of 184 [29%]) or a global level (57 of 184 [31%]). Global-level OHNs, which we define as operating across two or more regions, are mostly headquartered in either Europe (23 of 58 [40%]) or North America (12 of 58 [21%]), meaning that the governance and decision making of global OHNs is done predominantly in high-income countries (figure 1). Only six (10%) global-level OHNs have their headquarters in Africa, one (2%) has headquarters in Asia, and one (2%) has headquarters in South America.

These findings show the inconsistencies in access to and distribution of resources between high-income countries and low-income and middle-income countries, which are a major challenge to One Health partnerships and prevent equitable collaboration.[18,27,28] One Health, like global health, is not immune to pre-existing hierarchies that shape relational and operational dynamics in One Health policy and practice.[18,29] Low-income and middle-income countries and organisations are integral when setting up One Health research collaborations, but they are often marginalised or replaced by organisations from high-income countries and institutions.[30] Realisation that the One Health approach, as currently operationalised, might perpetuate current power and privilege dynamics that put high-income countries at the forefront of international collaborations has increased; low-income and middle-income organisations could have an equitable share of the collaboration.[31,32] As shown in a bibliometric analysis of publications on One Health by Miao and colleagues,[33] 28% of all publications were produced by authors based in the USA, 11% of all publications were produced by authors based in the UK, and 20 of the 21 most prolific authors during the study period were affiliated with institutions either in the USA or in Europe. Miao and colleagues[33] also ranked the USA highest regarding the strength of their international, cross-institutional collaboration in One Health research. It is imperative that OHNs, particularly those with a global focus, establish more egalitarian governance structures to ensure inclusive and equitable partnerships and agenda setting.

The Global Alliance for Rabies Control (GARC) is an example of an OHN with a global geographical focus and an agile, country-responsive governance structure (panel 1). In this Series paper, we define governance as the non-hierarchical coordination system that uses various mechanisms, including legal, financial, political,

Public Health, National University of Singapore and National University Health System, Singapore
(A Rahman-Shepherd)

Correspondence to:
Dr Athman Mwatondo, Zoonotic Disease Unit, Ministry of Health, Nairobi 00202, Kenya
amwatondo@yahoo.com

See Online for appendix

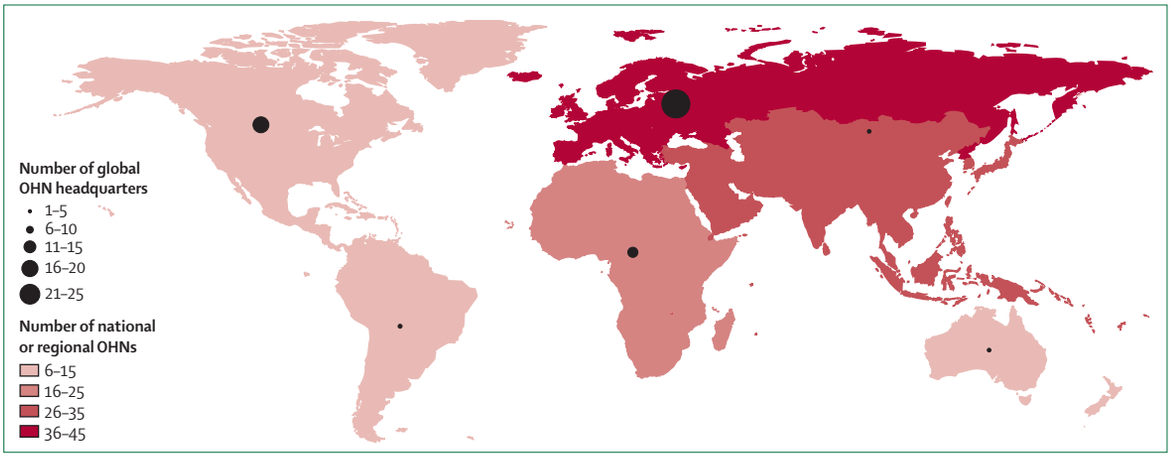

Figure 1: **Geographical distribution of OHNs**
OHN=One Health Network.

Panel 1: The devolved governance arrangements and standardised monitoring tools of GARC

The Global Alliance for Rabies Control (GARC) is a non-profit organisation that supports national and community-led rabies elimination efforts by providing specialised tools, expert advice, and technical assistance. To establish effective and sustainable change in the elimination of canine-mediated rabies, GARC and partners have generated a devolved series of inclusive rabies elimination networks. The first of these networks was the Partners for Rabies Prevention (PRP), an international One Health expert advisory group that decides policy, develops tools, and provides guidance on international best practices.[34] On June 18, 2018, the United Against Rabies Collaboration (UAR) was formed to develop a global strategic plan for the elimination of dog-mediated human rabies.[35]

One challenge for international bodies, such as PRP and UAR, is dissemination of findings and outcomes to individual countries. To address these challenges, GARC formed three regional rabies control networks that cover most of the dog-rabies endemic world: Pan-African Rabies Control Network (sub-Saharan Africa), Asian Rabies Control Network (south and east Asia), and Middle East, Eastern Europe, Central Asia and North Africa Rabies Control Network (Middle East, east Europe, central Asia, and north Africa).[36,37] These networks were formed by combining existing structures and unifying efforts into holistic regional networks, designed to prevent duplication of efforts and network structures. These rabies control networks are entirely focused on their allocated countries, with no formal headquarters, ensuring a diverse representation and a country-led approach. GARC acts as the secretariat to organise working meetings in which government representatives can confer, share ideas, and focus on developing or refining appropriate national and regional rabies elimination strategies.

The Stepwise Approach towards Rabies Elimination (SARE) tool exemplifies all aspects of One Health cohesion, sustainable approaches, and evidence-based interventions by helping governments understand the rabies situation at the national level, measuring progress of elimination activities and adhering to the overarching Global Strategic Plan.[38] Representatives from all groups involved in rabies control are invited to participate in these in-country workshops, including human and animal health sectors, local mayors associations, environmental control (waste management), wildlife, police, ministry of communication, education, civil society, and the private sector.[39] The SARE tool provides a tangible and standardised way of measuring progress within each country (ie, a monitoring and evaluation framework) and delivers an action plan to measure progress within individual countries and across the regional networks.[40] Through this process, the rabies control networks can generate regional rabies elimination strategies that have been developed through the combined efforts of all partners, with One Health representatives from national governments leading decision making.

diplomatic, technical, normative, and public mechanisms (civil society and media) to support network activities.[41] As GARC developed, it emphasised devolving governance arrangements to become more country-led; the GARC Secretariat has an administrative role and coordinates across regions, but the technical collaboration and implementation is led by national govenments and local partners. Use of governance structures that bring together countries and organisations from different contexts provides the means for equitable access to financial and material resources that can help to sustain centrality and positions of leadership for low-income and middle-income countries and organisations in One Health collaborations. The GARC governance model is a good example for other global OHNs currently headquartered in Europe or North America to devolve decision making

to a regional or national level and redistribute power and resource allocation more equitably across their geographical foci. This governance model can also help develop robust national health security strategies that can build and sustain the necessary skills and capacities across clinical, veterinary, public health, laboratory, and environmental services and encourage collaboration between regional and global institutions. For OHNs focused on endemic or neglected diseases, the GARC model shows the power of collective and specified actions from the community level to encourage increased collaboration and resource allocation at a national level.

Focuses and activities of OHNs

Many of the frameworks and tools developed to implement the International Health Regulations mandate a One Health approach to capacity building.[42] Thus, much of the momentum of One Health is the result of a focus on health security and emergent zoonotic threats to human health that have epidemic or pandemic potential.[43,44] The outbreak narrative, which highlights the risk of novel emerging and re-emerging diseases and their rapid spread globally, has historically led to financial support for One Health initiatives, which further directs resources to a restricted approach to One Health operationalisation at the expense of overcoming other priority issues and threats to health in diverse contexts.[28,43] The findings of this Series paper show the extent to which the outbreak narrative continues to characterise OHNs; of the 184 included OHNs, 105 (57%) focused on emerging and novel pathogens; 77 (42%) focused on endemic and neglected tropical diseases (NTDs); 44 (24%) focused on antimicrobial resistance; 37 (20%) focused on extreme weather, water security, and environmental degradation; 23 (13%) focused on food safety and food and nutrition security; and no information was found for 13 (7%) OHNs (figure 2). The focus areas of OHNs remained broadly consistent for the past 15 years, suggesting a continuing focus on health security priorities with little regard for upstream drivers of disease emergence (measures to address the preventing drivers of zoonotic disease re-emergence, outbreaks, and spread) or other crucial hazards and health emergencies risks.[45]

Despite the established evidence base supporting One Health operationalisation to prevent and control endemic infections and NTDs (alongside an increased disease burden from these hazards, shown in the first paper in this Series[46]), the most reported focus area for OHNs was emerging infections and novel pathogens. Other global health security hazards, such as food safety concerns and food and nutrition security or extreme weather, water security, and environmental degradation, are becoming increasingly crucial issues and remain under-represented as focus areas of OHNs. A similar finding was observed in Miao and colleagues'[33] bibliometric analysis, which identified a higher number of publications about zoonoses and antimicrobial resistance than about food safety and vector-borne diseases. These findings are concerning, not because emerging infections and novel pathogens do not justify high resource investment, but because there is an opportunity cost involved in competing for and allocating finite investments. This competition can lead to poor use of available resources, disaffection in local communities whose priorities are not being addressed, duplication of services, and a lack of communication or coordination between disciplines, leading to inefficiencies.[47] Ultimately, these costs risk exacerbating vulnerabilities in contexts with a high burden of other health security hazards of One Health relevance. We believe these insights into the current focus areas of OHNs provide funders of One Health with a guide for future investments to overcome deficits in OHN foci, rather than duplicating them.

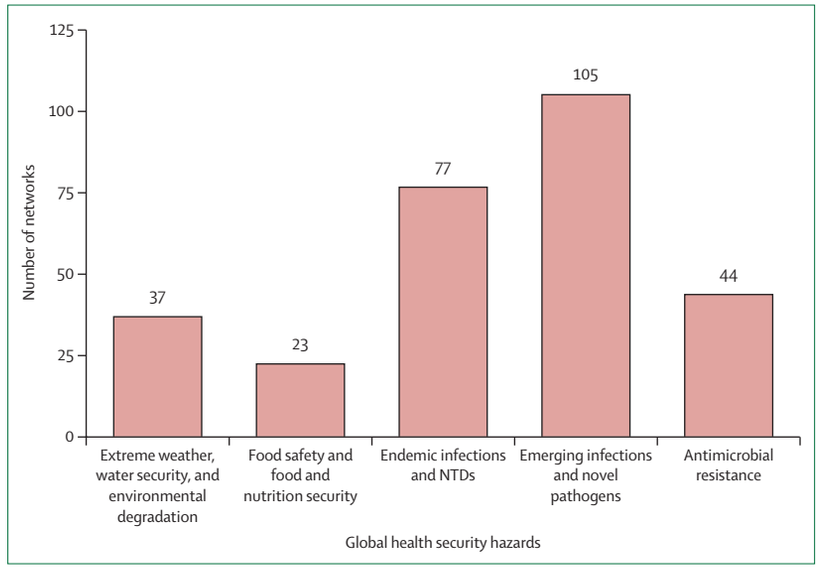

Figure 2: **Global health security hazard focuses of OHNs**
Most OHNs focus on more than one hazard category. NTDs=neglected tropical diseases. OHN=One Health Network.

The most common focus areas for OHNs were communication and collaboration (129 of 184 [70%]) through coordination of One Health sectors and activities, research (116 of 184 [63%]), and capacity building (116 of 184 [63%]). These activities were predominantly reported by academic OHNs. Other, less common focus areas included advocacy (45 of 184 [24%]), policy development (28 of 184 [15%]), and community engagement (25 of 184 [14%]). Since 2009, there has been a substantial increase in One Health research and capacity-building funding via global programmes. For example, the US Agency for International Development (USAID)-funded Emerging Pandemic Threats Program,[48] the Global Health Security Agenda, and the UK Fleming Fund.[49] Between 2014–18, the USAID Preparedness and Response Project supported the development and strengthening of One Health platforms in 16 countries in east Africa, west Africa, and southeast Asia,[50] and the Fleming Fund has strengthened capacities of and the evidence base for antimicrobial

For the **Global Health Security Agenda** see https://ghsagenda.org/

resistance surveillance in several countries (mainly in sub-Saharan Africa and Asia).[51] Few OHNs are involved in important areas such as policy development (15%) or community engagement (14%). However, the evidence base shows community involvement is pivotal to the success of One Health programmes, policies and research, and implementing policy or research output in practice.[52,53]

Although our analysis did not include the financial aspects of OHNs, it is crucial to assess the ways contexts, sectors, and stakeholders with increased access to political and financial resources might end up affecting the agenda and priorities of OHNs in the long term. These groups might have important effects on the quality and sustainability of investment in One Health infrastructure. For example, funding for more than 90% of One Health initiatives in sub-Saharan Africa comes from outside the continent.[3] As discussed by Fasina and colleagues,[3] "National One Health platforms [in Africa] will continually suffer setbacks, deliver externally-programmed outcomes, and risk unsustainability if the dependence on donor-funding continues."[3] They emphasise the importance of establishing the necessary policies and legal tools at a national, regional, and continental level to facilitate full implementation of One Health activities in sub-Saharan Africa. Efforts between One Health donors and OHNs should be increased to provide the infrastructure required for sustainable implementation of One Health. These discussions should include variable burden of infectious and zoonotic disease threats and the context-specific drivers (factors that directly or indirectly influence the occurence and spread of disease) linked to endemic poverty, growing food insecurity, threatened livelihoods, desertification, and flooding.[3] Investors should recognise and be guided by the strong evidence base showing the added value and cost savings of One Health approaches in low-income and middle-income contexts in tackling health security threats.[30,54,55]

64 (35%) of the 184 OHNs we identified were short-term projects or programmes. Although projects are almost always time-bound, with clear outputs expected within the implementation period, their short-term nature and focus on the priorities of the funder might prevent genuine OHN partnerships and collaboration and adversely affect the achievement of long-term outcomes for local communities.

An example of an OHN working on issues that most affect local communities is the One Health for Humans, Environment, Animals and Livelihoods (HEAL) project (panel 2). The HEAL project applies a One Health approach to overcome health security threats affecting pastoral communities in the geographical Horn of Africa,

Panel 2: The community and the environment as priorities for a One Health Network

The Horn of Africa is home to millions of pastoralists, primarily nomadic, living in arid and semi-arid areas. Pastoral communities depend on livestock for their daily livelihoods. Nomadic pastoralism is beneficial to communities through optimal use of drylands and contributes millions of US dollars to national economies through the sale of livestock and livestock products.[56,57] However, this model has many challenges, including socioeconomic neglect, climatic variability, increasingly frequent droughts, and recurrent violent conflicts characterised by resource competition over scarce grazing land and water.[58,59]

The One Health for Humans, Environment, Animals and Livelihoods (HEAL) project was initiated in 2019, with a primary objective of applying a One Health approach to enhance the wellbeing and resilience of vulnerable communities in pastoral and agro-pastoral areas of Ethiopia, Kenya, and Somalia. The HEAL project was conceived to overcome the unique challenges pastoral communities have in seeking high-quality human health and veterinary services and sustainably managing their environment and natural resources. The project is implemented at a regional level in Ethiopia, Kenya, and Somalia.[60] The One Health for HEAL is led by the Veterinaires Sans Frontieres-Suisse in partnership with Comitato Collaborazione Medica and the International Livestock Research Institute. Since initiation in 2019, the project has completed a 20-month inception phase. This phase included activities aimed at understanding the health service needs of the communities, the national-level One Health policy context, and the levels of institutionalisation of One Health in priority countries such as Ethiopia, Kenya, and Somalia. One of the achievements of HEAL during the inception phase was the completed One Health policy context and needs assessment in Ethiopia, Kenya, and Somalia. The assessment focused on important areas, including priority zoonoses, One Health institutionalisation, and deficits in One Health implementation in the three countries.

HEAL focuses on the community, prioritising local needs and establishing local mechanisms to improve health, veterinary services, and environmental issues. This approach increases community participation, enabling the project to identify local priorities that lead to context-specific and needs-based solutions across the spectra of human, animal, and environmental health. For example, the HEAL project supports existing community structures, such as the rangeland management units, to manage and monitor rangeland health and overcome a wide array of complex health, ecosystem, and food security issues, such as the proliferation of invasive plant species (eg, *Prosopis juliflora*), dengue virus in humans, and contagious caprine pleuropneumonia in livestock.[61] The project has started a 4-year pilot phase, during which the integrated service delivery through One Health Units will be done in various communities and will provide evidence for policy makers that can be used to strengthen service delivery in pastoral communities that are often neglected.

For **HEAL** see https://www.oh4heal.org/heal/

recognising challenges to sustainable livelihoods. HEAL invested the first 20 months of project initiation in doing community-led needs assessments to inform project activities. They ensured local ownership by inviting communities to play a direct role in deciding the agenda and priorities of the project, thereby making it accountable to local stakeholders. Local prioritisation of investment is integral to effective and sustainable health programming and should be done by all One Health initiatives.[62]

OHN formation and partnership

One of the main barriers to interdisciplinarity (combining or involving two or more academic or research disciplines into an activity), characterised by Lélé and Norgaard,[63] is the "relative absence of motivation" to cross disciplinary boundaries. Spencer and colleagues[44] argue that the organisations leading the One Health movement have not developed the necessary collaboration-building skills to overcome such barriers for various reasons, including an emphasis on showing the effects and benefits of One Health approaches on human health, a perceived lack of respect for disciplinary differences, and an unwillingness to understand sectoral and organisational cultures.[27,28,43,44,63] The challenge to true multisectoral collaboration was clear in the findings of this Series paper: despite our search strategy being deliberately broad to capture initiatives with One Health potential, only 111 (60%) of 184 included OHNs engaged all three sectors (human health, animal health, and the environment or ecosystems). The remaining OHNs engaged a combination of two sectors. 182 (99%) of OHNs involved the human health sector, 164 (89%) involved the animal health sector, and 133 (72%) involved the environment sector. This under-representation of the environment and ecosystems is shown in One Health publications in which current studies focus on human and animal health, with little attention paid to environmental health issues.[33] Only 52 (28%) of the 184 included OHNs mentioned wildlife health, suggesting that there is a greater focus on domesticated animals than on wildlife animals within animal health.

The neglect of environment or ecosystem organisations in One Health has been a persistent criticism of the movement and a widely recognised impediment to operationalisation.[30,64] Dominant sectors and stakeholders, typically from the human and public health community, can affect the One Health agenda and direct resources and political and financial attention to issues they perceive to be a priority.[44] The establishment of the Quadripartite promises to change this traditional neglect of the environment sector and could encourage future OHNs to include concerns of air pollution, water use, biodiversity, and climate change.[12]

Equitable and appropriate One Health collaboration recognises the interdisciplinarity required to mitigate the effects and implications of shared health threats and encourages it when making decisions. The Health for Animals and Livelihood Improvement project[65] describes a whole-of-society approach to be used by everyone from government officials to wildlife game wardens, village leaders, and community households. This approach would inform policy with evidence grounded in the realities of specific Indigenous communities (panel 3). It is important to create ways for local communities to share findings and seek guidance, as well as a crucial aspect of good governance and accountability. Similarly, in-country workshops held by the regional networks of GARC involve various local stakeholders, including local mayors associations, waste management, and law enforcement, to ensure that inclusivity is at the forefront of policy design and implementation. This type of inclusive participation leads to mutuality and minimises unintended or unanticipated effects of threats from shared interfaces on the health of other sectors, populations, communities, or ecosystems. As the COVID-19 pandemic has shown, preparedness and response capacity building require engaging multisectoral stakeholders and encouraging their participation in decision making. However, our results show a substantial deficit in community engagement, which potentially reduces the extent to which OHNs can overcome the effects of threats arising from shared systems interfaces. OHNs were predominantly comprised of a combination of academic or research institutions (132 of 184 [72%]), non-governmental organisations or civil societies (92 of 184 [50%]), and government departments (92 of 184 [50%]). The private sector (17 of 184 [9%]) is under-represented in OHNs; it should be involved in health system decisions as it is also important in health infrastructure access and service delivery and often directly exacerbates or mitigates factors of disease emergence and transmission.[71,72]

As partnerships develop and improve, Buse and Tanaka[27] argue that management strategies and structures are increasingly crucial to optimise performance, more than having a shared goal or commitment. However, OHNs frequently function without established accountability structures or without making these structures publicly available, such as in published monitoring and evaluation frameworks or periodic programme evaluations.[1] Transparent reporting structures about OHN progress would enable assessment of any collective maximisation of resource allocation by OHNs. For example, the Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP) attributes much of its longevity to the systemised production of its respected and widely referenced annual report, which attracts a wide range of important stakeholders from policy makers to industry individuals (panel 4). Similarly, the devolved governance arrangements of GARC are supported by the robust and standardised implementation of monitoring tools and activities, which all countries within the regional networks use. These OHNs clearly show the benefits of establishing monitoring and evaluation frameworks that are robustly implemented and that are published and

Panel 3: The One Health approach of HALI

The Health for Animals and Livelihood Improvement (HALI) project is a collaborative One Health research and capacity-strengthening initiative led by the University of California Davis One Health Institute (Davis, CA, USA) and Sokoine University of Agriculture (Morogoro, Tanzania).[66] Using this partnership, the HALI project has cultivated an international team that works together to understand the interactions between humans, animals, and their shared environments in Tanzania. Since 2006, the HALI team has managed more than US$10 million in donor and grant funds, nurtured 18 international partnerships, trained 2000 individuals, and supported the infrastructure and development of multiple laboratories in Tanzania, thereby strengthening national systems for zoonotic disease prevention, detection, and response.

Apart from these achievements, the biggest success of the HALI project has been increasing collaboration between policy makers and communities, using a One Health approach to put technical knowledge into a practical social context that has diverse stakeholders. Community outreach and engagement is widely considered crucial for successful implementation of research, development, and intervention programmes. However, there are too few initiatives that seriously consider outreach as essential for implementation or that account for stakeholder engagement throughout a project.[67] Funding from the US Agency for International Development was essential for the HALI team to integrate elements of development practice and participatory action research into its culture, and intensive stakeholder engagement has been involved in all projects.

The HALI project[65] used a whole-of-society approach, having meetings with stakeholders and potential beneficiaries to solicit input and feedback and to cultivate relationships for effective implementation of project activities. Putting One Health principles into practice, this approach was multisectoral and transdisciplinary.[68] HALI teams engaged ministry officials, regulatory organisations, ethics committees, and policy platforms, such as the Tanzania One Health Coordination Desk. At the subnational level, the HALI project engaged and trained personnel ranging from regional laboratory scientists and district medical and veterinary officers to community health workers and resource managers, effectively establishing district-level One Health platforms. At the community level, the HALI team worked with ward executive officers, village executive officers, wildlife game wardens, and village chairmen; used focus groups; and worked directly with households to ensure they had input into work being done. The approach has prioritised accountability and inclusivity.

As the projects progressed, the HALI teams worked directly with stakeholders to design and deliver outreach that communicates research findings in accessible ways.[69] Outreach campaigns have been incorporated into project budgets to show findings to the ministries and local government authorities through workshops and seminars and show findings to Indigenous communities through town halls and village tours. In the villages, feedback frequently indicates that HALI teams have been one of the few groups to ever return and share findings, showing that colonial attitudes and a lack of accountability to local communities persists in many research cultures. However, there is an increasing realisation that establishing trust with local communities is crucial for the success of One Health, especially for health interventions (shown during the Ebola virus disease epidemic in west Africa, the Ebola virus outbreaks in DR Congo, and the COVID-19 pandemic).[70] The HALI project is an example of an applied, whole-of-society One Health approach that other One Health Networks can use.

open to peer and public scrutiny. Establishing appropriate reporting infrastructure will enable OHNs to contribute data to the current evidence base, quantifying the added value of collaborative interdisciplinary approaches. This process will be necessary to restructure and increase the financing available for more integrated, non-disease-specific OHN formation. To support such operational planning, the focus on capacity-building activities related to policy development and financing should increase. Only a few OHNs appear to engage in policy development (28 of 184 [15%]) or the disbursement of funds (4 of 184 [2%]). Without this emphasis, OHNs will not start to develop sufficiently transparent and accountable internal management systems.

Lessons for sustainable OHN investment and formation

The COVID-19 pandemic has shown the world that global health security relies on the ability of health systems collectively to prepare for, prevent, and respond to transboundary threats of epidemic and pandemic potential. As a novel pathogen, SARS-CoV-2 showed the need to apply One Health perspectives when examining factors that lead to occurence of health security threats. However, One Health organisations should not forget other health security threats or the ability of OHNs to establish adaptive governance models and resource allocation to contextualise health security at local levels of the global system and maintain intersectoral collaborations during interepidemic time periods.

Investment in One Health should focus on strengthening the governance foundations of One Health initiatives, particularly when they involve multiple institutional and international partners. This focus will ensure that investment is equitable, country-led, country-owned, and community-oriented. Not only do these important guiding principles increase the sustainability of One Health investments, but they are also an important

Panel 4: Annual reporting leads to sustainability for DANMAP

The Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP) is one of the oldest One Health Networks (OHNs) in Denmark, started as an initiative by scientists at different institutions who were keen to understand the relation between antibiotics for animals and their possible effects on human health through the transmission of antibiotic-resistant bacteria.[73,74] In addition to being a publicly funded monitoring programme, DANMAP is a platform for mutual collaborative efforts between the animal health, food safety, and human health sectors. It is an established One Health collaboration integrated into government programmes on human and animal health that has equal representation at political, scientific, and executive levels.

The most important reason for the longevity of DANMAP might be the established annual report. There have been defined deliverables, regular outputs, and a stringent schedule related to the production of an annual report since 1995, delivered by a team of six people employed by the Statens Serum Institut (Copenhagen, Denmark) and the National Food Institute (Lyngby, Denmark).[75] Members of the DANMAP team are also part of the National Antibiotic Council of the Ministry of Health, of advisory boards for food safety and animal health authorities, and of research investigating resistance mechanisms and patterns in different bacteria. Contributions to the report come from a large network of experts. The cross-sector arrangement and its continuous use of specialists and stakeholders from many other sectors facilitates flexibility, adjustability, and familiarity if the OHN has to respond to other issues, such as emerging threats or policy advice. The report is another motivator that affects sustainability, as DANMAP requires evaluation of its policy programmes, detection of emerging trends of antimicrobial resistance, and public awareness of antimicrobial resistance.

Working as an OHN is resource-demanding. DANMAP is consistently challenged by other programmes competing for resources, by emerging issues that require expertise, and by resistance to change because of institutional apathy and respect for tradition. However, the demand for the annual product by industries, policy, the public, clinicians, international communities, and specialists has established and sustained DANMAP for 25 years. In 2021, DANMAP published its 25th jubilee report with transparency and mutual trust highlighted as important features for the success of the OHN. As the archetype for cross-sectoral national surveillance of resistance and use of antimicrobials, DANMAP has been the basis for many preventive measures and regulations, for which Denmark receives international recognition.

starting point to redistribute power from high-income contexts and organisations, where it is currently concentrated. As the One Health approach gains increased political and financial attention, current inequities in resource allocation and knowledge production that have been identified in research are addressed as part of advancing One Health implementation. There are valuable lessons and practices that One Health organisations can implement, such as increasing efforts to establish more equitable praxis in global health. For example, since 2021, in recognition of the colonial history of Canada, the Canadian Institutes of Health Research have held dedicated engagements with Indigenous communities to discuss how the Institutes can address systemic racism in health research funding.[76] Similar initiatives should be encouraged in other loci of global health research and development funding.

To make One Health more equitable and inclusive than it currently is, we propose three important lessons for the global One Health community to consider. First, OHNs should encourage mutual collaboration and cooperation on the basis of appropriate governance arrangements and management strategies between stakeholders, as shown by GARC and DANMAP. Second, OHNs should calibrate and balance power to ensure country leadership and ownership of activities; investment in OHNs should be driven by local needs and priorities, not by donor priorities. Finally, OHNs should include community stakeholders in their partnership structures and governance arrangements to meaningfully engage with local realities and establish priorities for action. This final lesson is an important one for the custodians of the International Health Regulations and other global agencies who primarily engage with government ministries and have insufficient consultation with community organisations or marginalised groups when supporting the development of national action plans for health security. The HEAL project is already showing how this approach, with a focus on endemic and existential issues, can increase local capacity and trust between local communities and OHNs. We argue that this approach will enable OHNs to manage and respond to high-impact, low-probability events, such as COVID-19, that typically dominate health security agendas and funding priorities.

In conclusion, external funding and domestic resourcing of OHNs should be balanced. Currently, external donors from Europe and North America have too much influence over allocating resources and establishing priorities; the patterns of One Health engagement identified in this Series paper between high-income, middle-income, and low-income countries ultimately risk the sustainability of OHNs. There is a need to increase domestically available financial resources for national and subnational OHNs (from the public, private, or philanthropic sector) to reduce dependency on external financing and donor countries, as argued by Fasina and colleagues.[3] OHNs should evaluate

their current partnership structures and use the principles of equity, transparency, and sustainability to effectively overcome threats to global health security.

Contributors

OD, DH, RKo, and AZ conceptualised the *Lancet* Series on One Health and developed the outline for the papers. The study design is inspired by the work of JS and MK and has been adapted by AM, AR-S, BC, LH, and OD. AM, LH, BC, LBA, DE, MMutun, MMutur, SMT, MA, and NM performed the initial search and collected and extracted the data; AM, AR-S, BB, MK, JS, and LH analysed the data. AM, JM, SC, KKK, and OAH did the additional search (from 2020 to 2022) and updated the data collection, extraction, and analysis. ZI, RKa, LHN, TPS, ZS, KS, UWS, DW, DO, and JE-I drafted the case studies. AM and AR-S provided the first draft of the manuscript and have contributed to the manuscript equally. RKo, AZ, DH, MK, JS, SC, KKK, OAH, OD, and FN edited and contributed to several drafts of the manuscript. All authors contributed to the writing and finalisation of the manuscript.

Declaration of interests

We declare no competing interests.

Acknowledgments

OD, RKo, AZ, DH, SC, KKK, and FN are members of, and acknowledge support for their contributions to the manuscript from, the Pan-African Network For Rapid Research, Response, Relief and Preparedness for Infectious Disease Epidemics, funded by the European and Developing Countries Clinical Trials Partnership, under the EU Horizon 2020 Framework Programme for Research and Innovation.

References

1 Khan MS, Rothman-Ostrow P, Spencer J, et al. The growth and strategic functioning of One Health networks: a systematic analysis. *Lancet Planet Health* 2018; **2:** e264–73.

2 Lee K, Brumme ZL. Operationalizing the One Health approach: the global governance challenges. *Health Policy Plan* 2013; **28:** 778–85.

3 Fasina FO, Fasanmi OG, Makonnen YJ, Bebay C, Bett B, Roesel K. The One Health landscape in sub-Saharan African countries. *One Health* 2021; **13:** 100325.

4 Food and Agricultural Organization of the UN, World Organisation for Animal Health, WHO. The FAO–OIE–WHO collaboration: a Tripartite concept note. 2010. https://www.who.int/publications/m/item/the-fao-oie-who-collaboration (accessed June 24, 2022).

5 Kock RA, Karesh WB, Veas F, et al. 2019-nCoV in context: lessons learned? *Lancet Planet Health* 2020; **4:** e87–88.

6 Zumla A, Dar O, Kock R, et al. Taking forward a 'One Health' approach for turning the tide against the Middle East respiratory syndrome coronavirus and other zoonotic pathogens with epidemic potential. *Int J Infect Dis* 2016; **47:** 5–9.

7 Haider N, Rothman-Ostrow P, Osman AY, et al. COVID-19—zoonosis or emerging infectious disease? *Front Public Health* 2020; **8:** 596944.

8 WHO. WHO Director-General's opening remarks at 148th session of the Executive Board. 2021. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-148th-session-of-the-executive-board (accessed June 24, 2022).

9 WHO. 26 international experts to kickstart the One Health High Level Expert Panel (OHHLEP). 2021. https://www.who.int/news/item/11-06-2021-26-international-experts-to-kickstart-the-joint-fao-oie-unep-who-one-health-high-level-expert-panel-(ohhlep) (accessed June 24, 2022).

10 Adisasmito WB, Almuhairi S, Behravesh CB, et al. One Health: a new definition for a sustainable and healthy future. *PLoS Pathog* 2022; **18:** e1010537.

11 WHO. Tripartite and UNEP support OHHLEP's definition of "One Health". 2021. https://www.who.int/news/item/01-12-2021-tripartite-and-unep-support-ohhlep-s-definition-of-one-health (accessed June 24, 2022).

12 WHO. Quadripartite Memorandum of Understanding (MoU) signed for a new era of One Health collaboration. 2022. https://www.who.int/news/item/29-04-2022-quadripartite-memorandum-of-understanding-(mou)-signed-for-a-new-era-of-one-health-collaboration (accessed June 24, 2022).

13 King LJ, Anderson LR, Blackmore CG, et al. Executive summary of the AVMA One Health Initiative Task Force report. *J Am Vet Med Assoc* 2008; **233:** 259–61.

14 Atlas RM. One Health: its origins and future. *Curr Top Microbiol Immunol* 2013; **365:** 1–13.

15 Zinsstag J, Schelling E, Waltner-Toews D, Tanner M. From "One Medicine" to "One Health" and systemic approaches to health and well-being. *Prev Vet Med* 2011; **101:** 148–56.

16 Leboeuf A. Making sense of One Health. Cooperating at the human–animal–ecosystem health interface. 2011. http://www.academia.edu/633338/Making_sense_of_One_Health (accessed June 24, 2022).

17 Stephen C, Stemshorn B. Leadership, governance and partnerships are essential One Health competencies. *One Health* 2016; **2:** 161–63.

18 Larkan F, Uduma O, Lawal SA, van Bavel B. Developing a framework for successful research partnerships in global health. *Global Health* 2016; **12:** 17.

19 Rüegg SR, Nielsen LR, Buttigieg SC, et al. A systems approach to evaluate One Health initiatives. *Front Vet Sci* 2018; **5:** 23.

20 PANORAMA. PANORAMA One Health. 2022. https://panorama.solutions/en/portal/panorama-one-health?page=1 (accessed July 7, 2022).

21 EcoHealth Alliance. Emerging infectious diseases—South East Asia Research Collaboration Hub. https://www.ecohealthalliance.org/program/south-east-asia-research-collaboration-hub (accessed June 24, 2022).

22 Centers for Research in Emerging Infectious Diseases Network. Overview of CREID network. 2020. https://creid-network.org/about (accessed June 24, 2022).

23 Wilder-Smith A, Osman S. Public health emergencies of international concern: a historic overview. *J Travel Med* 2020; **27:** taaa227.

24 Joint Programming Initiative on Antimicrobial Resistance. About JPIAMR. 2015. https://www.jpiamr.eu/about/ (accessed June 24, 2022).

25 One Health European Joint Programme. First annual scientific meeting of the One Health European Joint Programme (OH EJP) on food-borne zoonoses, antimicrobial resistance, and emerging threats. 2019. https://onehealthejp.eu/annual-scientific-meeting-2019/ (accessed June 24, 2022).

26 WHO. Global action plan on antimicrobial resistance. 2016. https://www.who.int/publications/i/item/9789241509763 (accessed June 24, 2022).

27 Buse K, Tanaka S. Global public-private health partnerships: lessons learned from ten years of experience and evaluation. *Int Dent J* 2011; **61** (suppl 2): 2–10.

28 Stephen C, Karesh WB. Is One Health delivering results? *Rev Sci Tech* 2014; **33:** 375–92.

29 Errecaborde KM, Macy KW, Pekol A, et al. Factors that enable effective One Health collaborations—a scoping review of the literature. *PLoS One* 2019; **14:** e0224660.

30 Valeix S. Towards One Health: evolution of international collaboration networks on Nipah virus research from 1999–2011. 2014. http://steps-centre.org/wp-content/uploads/Networks.pdf (accessed June 24, 2022).

31 Baquero OS, Benavidez Fernández MN, Acero Aguilar M. From modern Planetary Health to decolonial promotion of One Health of peripheries. *Front Public Health* 2021; **9:** 637897.

32 Lainé N, Morand S. Linking humans, their animals, and the environment again: a decolonized and more-than-human approach to "One Health". *Parasite* 2020; **27:** 55.

33 Miao L, Li H, Ding W, et al. Research priorities on One Health: a bibliometric analysis. *Front Public Health* 2022; **10:** 889854.

34 Lembo T, Attlan M, Bourhy H, et al. Renewed global partnerships and redesigned roadmaps for rabies prevention and control. *Vet Med Int* 2011; **2011:** 923149.

35 Minghui R, Stone M, Semedo MH, Nel L. New global strategic plan to eliminate dog-mediated rabies by 2030. *Lancet Glob Health* 2018; **6:** e828–29.

36 Scott TP, Coetzer A, de Balogh K, Wright N, Nel LH. The Pan-African Rabies Control Network (PARACON): a unified approach to eliminating canine rabies in Africa. *Antiviral Res* 2015; **124:** 93–100.

37 Coetzer A, Scott TP, Amparo AC, Jayme S, Nel LH. Formation of the Asian Rabies Control Network (ARACON): a common approach towards a global good. *Antiviral Res* 2018; **157:** 134–39.

38 Scott TP, Coetzer A, Nel LH. Strategies for the elimination of dog-mediated human rabies by 2030. In: Fooks AR, Jackson AC, eds. Rabies. London: Elsevier, 2020: 671–88.

39 Valenzuela LM, Jayme SI, Amparo ACB, et al. The Ilocos Norte communities against Rabies Exposure Elimination Project in the Philippines: epidemiological and economic aspects. *Front Vet Sci* 2017; **4:** 54.

40 Coetzer A, Kidane AH, Bekele M, et al. The SARE tool for rabies control: current experience in Ethiopia. *Antiviral Res* 2016; **135:** 74–80.

41 Kickbusch I, Szabo MMC. A new governance space for health. *Glob Health Action* 2014; **7:** 23507.

42 WHO. International Health Regulations. *Perspect Public Health* 1971; **91:** 109.

43 Galaz V, Leach M, Scoones I, Stein C. The political economy of One Health research and policy. Brighton: STEPS Centre, 2015.

44 Spencer J, McRobie E, Dar O, et al. Is the current surge in political and financial attention to One Health solidifying or splintering the movement? *BMJ Glob Health* 2019; **4:** e001102.

45 Berthe FCJ, Bouley T, Karesh WB, et al. Operational framework for strengthening human, animal and environmental public health systems at their interface. Washington, DC: World Bank Group, 2018.

46 Zinsstag J, Kaiser-Grolimund A, Heitz-Tokpa K, et al. Advancing One human–animal–environment Health for global health security: what does the evidence say? *Lancet* 2023; published online Jan 19. https://doi.org/10.1016/S0140-6736(22)01595-1.

47 Nyatanyi T, Wilkes M, McDermott H, et al. Implementing One Health as an integrated approach to health in Rwanda. *BMJ Glob Health* 2017; **2:** e000121.

48 Kelly TR, Machalaba C, Karesh WB, et al. Implementing One Health approaches to confront emerging and re-emerging zoonotic disease threats: lessons from PREDICT. *One Health Outlook* 2020; **2**: 1–7.

49 Dacombe R, Pulford J, Wallis S, Bhardwaj M, Bates I. Fleming Fund: supporting surveillance capacity for antimicrobial resistance Regional Networks and Educational Resources. Project Report. 2016. http://researchonline.ljmu.ac.uk/id/eprint/6679/ (accessed June 24, 2022).

50 Kitua AY, Scribner S, Rasmuson M, et al. Building a functional national One Health platform: the case of Tanzania. *One Health Outlook* 2019; **1**: 1–12.

51 Gordon N, Aggarwal V, Amos B, et al. The UK Fleming Fund: developing AMR surveillance capacity in low- and middle-income countries. *Int J Infect Dis* 2020; **101:** 40.

52 Henley P, Igihozo G, Wotton L. One Health approaches require community engagement, education, and international collaborations—a lesson from Rwanda. *Nature Medicine* 2021; **27**: 947–48.

53 Cleaveland S, Sharp J, Abela-Ridder B, et al. One Health contributions towards more effective and equitable approaches to health in low- and middle-income countries. *Philos Trans R Soc Lond B Biol Sci* 2017; **372:** 20160168.

54 Zinsstag J, Schelling E, Roth F, Bonfoh B, de Savigny D, Tanner M. Human benefits of animal interventions for zoonosis control. *Emerg Infect Dis* 2007; **13:** 527–31.

55 Zinsstag J, Utzinger J, Probst-Hensch N, Shan L, Zhou XN. Towards integrated surveillance-response systems for the prevention of future pandemics. *Infect Dis Poverty* 2020; **9:** 140.

56 Nyariki DM, Amwata DA. The value of pastoralism in Kenya: application of total economic value approach. *Pastoralism* 2019; **9:** 9.

57 Krätli S, Huelsebusch C, Brooks S, Kaufmann B. Pastoralism: a critical asset for food security under global climate change. *Anim Front* 2013; **3:** 42–50.

58 Smith AB. Modern pastoralism and conservation: old problems, new challenges. *J Peasant Stud* 2015; **42:** 1063–65.

59 Pavanello S. Pastoralists' vulnerability in the horn of Africa: exploring political marginalization, donors' policies, and cross-border issues literature review. 2009. https://odi.org/en/publications/pastoralists-vulnerability-in-the-horn-of-africa-exploring-political-marginalisation-donors-policies-and-cross-border-issues/ (accessed June 24, 2022).

60 One Health for HEAL. About One Health for HEAL. 2019. https://www.oh4heal.org/heal/ (accessed June 24, 2022).

61 Ibrahim II, Salza A. Technical report on a One Health operational research in the framework of HEAL. 2019. https://www.oh4heal.org/wp-content/uploads/2020/09/GEDO-anthropology-research_report-final.pdf (accessed June 24, 2022).

62 Salyer SJ, Silver R, Simone K, Barton Behravesh C. Prioritizing zoonoses for global health capacity building—themes from One Health zoonotic disease workshops in 7 countries, 2014–2016. *Emerg Infect Dis* 2017; **23:** S57–64.

63 Lélé S, Norgaard RB. Practicing interdisciplinarity. *Bioscience* 2005; **55:** 967–75.

64 Essack SY. Environment: the neglected component of the One Health triad. *Lancet Planet Health* 2018; **2:** e238–39.

65 Ortenzi F, Marten R, Valentine NB, Kwamie A, Rasanathan K. Whole of government and whole of society approaches: call for further research to improve population health and health equity. *BMJ Glob Health* 2022; **7:** e009972.

66 Mazet JAK, Clifford DL, Coppolillo PB, Deolalikar AB, Erickson JD, Kazwala RRA. A "One Health" approach to address emerging zoonoses: the HALI project in Tanzania. *PLoS Med* 2009; **6:** e1000190.

67 Sherman MH, Ford J. Stakeholder engagement in adaptation interventions: an evaluation of projects in developing nations. *Climate Policy* 2014; **14**: 417–41.

68 Bird BH, Mazet JAK. Detection of emerging zoonotic pathogens: an integrated One Health approach. *Annu Rev Anim Biosci* 2018; **6:** 121–39.

69 Gustafson CR, VanWormer E, Kazwala R, et al. Educating pastoralists and extension officers on diverse livestock diseases in a changing environment in Tanzania. *Pastoralism* 2015; **5:** 1–12.

70 Saylors K, Wolking D, Hagan E, et al. Socializing One Health: an innovative strategy to investigate social and behavioral risks of emerging viral threats. *One Health Outlook* 2020; **3:** 11.

71 World Economic Forum. Managing the risk and impact of future epidemics: options for public–private cooperation. 2015. https://www.weforum.org/reports/managing-risk-and-impact-future-epidemics-options-public-private-cooperation (accessed June 24, 2022).

72 Bishai D, Sachathep K. The role of the private sector in health systems. *Health Policy Plan* 2015; **30** (suppl 1)**:** i1.

73 Bager F. DANMAP: monitoring antimicrobial resistance in Denmark. *Int J Antimicrob Agents* 2000; **14:** 271–74.

74 Hammerum AM, Heuer OE, Emborg HD, et al. Danish integrated antimicrobial resistance monitoring and research program. *Emerg Infect Dis* 2007; **13:** 1632–39.

75 Statens Serum Institut. Reports. 2021. https://www.danmap.org/Reports (accessed June 24, 2022).

76 Datta G, Siddiqi A, Lofters A. Transforming race-based health research in Canada. *CMAJ* 2021; **193:** E99–100.