The growth and strategic functioning of One Health networks: a systematic analysis

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Summary

Background The recent increase in attention to linkages between human health, animal health, and the state of the environment has resulted in the rapid growth of networks that facilitate collaboration between these sectors. This study ascertained whether duplication of efforts is occurring across networks, which stakeholders are being engaged, and how frequently monitoring and evaluation of investments is being reported.

Methods This study is a systematic analysis of One Health networks (OHNs) in Africa, Asia, and Europe. We defined an OHN as an engagement between two or more discrete organisations with at least two of the following sectors represented: animal health, human health, and the environment or ecosystem. Between June 5 and Sept 29, 2017, we systematically searched for OHNs in PubMed, Google, Google Scholar, and relevant conference websites. No language restrictions were applied, but we were only able to translate from English and French. Data about OHNs, including their year of initiation, sectors of engagement, regions of operation, activities conducted, and stakeholders involved, were extracted with a standardised template and analysed descriptively.

Findings After screening 2430 search results, we identified and analysed 100 unique OHNs, of which 86 were formed after 2005. 32 OHNs covered only human and animal health, without engaging with the role of the environment on health. 78 OHNs involved academic bodies and 78 involved government bodies, with for-profit organisations involved in only 23 and community groups involved in only ten. There were few collaborations exclusively between networks in the developing world (four OHNs) and only 15 OHNs reported monitoring and evaluation information. The majority of OHNs worked on supporting communication, collaboration, information sharing, and capacity building.

Interpretation Amid concerns about there being insufficient strategic direction and coordination in the growth of OHNs, our study provides empirical evidence about limitations in stakeholder representation, apparently absent or ambiguous monitoring and evaluation structures, and potential areas of duplication. The collective strategic functioning of OHNs might be improved by more transparent reporting of goals and outcomes of OHN activities, as well as more collaborations led by networks within the developing world and increased attention to environmental health.

Funding None.

Introduction

Over the past 15 years, there has been increasing recognition of how human health is fundamentally linked to animal health and the state of the environment.[1] This understanding has been driven partly by a range of challenges that threaten to reverse the gains in health made in the 20th century. These challenges include the more regular emergence and re-emergence of infectious diseases arising from animal reservoirs—such as highly pathogenic avian influenza and rabies—the rise in antimicrobial resistance due in part to the inappropriate use of antibiotics in human and animal populations, climate change and the effects of growing human and animal populations, and increasing concerns around food security and water quality in vulnerable countries.[2–4]

One Health is a broad approach that facilitates interdisciplinary, multi-disciplinary, and transdisciplinary collaboration between the human health, animal health, and environment sectors.[5,6] We use the term multi-disciplinary to collectively refer to these collaborations, given that the nature of the collaboration might not always be known.[7] Although there is no consensus definition of One Health, and other terms, such as EcoHealth and planetary health, are also used in this context, the idea that improvements in health could be achieved by fostering greater multidisciplinary collaboration between the human, animal, and environmental sectors has garnered increasing political attention and financial support.[6,8]

In this Article, we use the term One Health to refer to approaches that recognise the link between human health, animal health, and the environment because this term has been formally endorsed and promoted by a range of multilateral agencies, including WHO, the

Research in context

Evidence before this study

As political and financial support for collaborations that recognise the effects of animal health and the environment on human health has grown, stakeholders from public, private for-profit, academic, and non-profit sectors have united to organise and facilitate One Health-related initiatives at the global, regional, and national levels. However, concerns have been expressed about the lack of coordination and possible resultant inefficiencies in the growth of One Health initiatives. Although there are a small number of studies about One Health networks (OHNs) operating globally, to our knowledge there have been no systematic and comprehensive analyses. Accordingly, there is insufficient evidence to establish if duplication of efforts is occurring, whether relevant stakeholders are being appropriately engaged, and to what extent monitoring and evaluation of investments in One Health organisations are being done.

Added value of this study

To our knowledge, this is the first study to systematically identify and analyse the operations of OHNs. Our results show that there has been an increase in the number of OHNs, especially since 2005. Most OHNs involved academic

institutions and government bodies, whereas private for-profit organisations and community groups were less frequently represented. Although 63% of OHNs reported activities across all three One Health sectors (animal, human, and environment), almost a third covered only human and animal health. Activities and collaborations that address the crucial role of the external environment on human and animal health were therefore under-represented. We found very few OHNs operating exclusively in the developing world and that little information was presented on the activities done by OHNs. We also identified a specific lack of information about monitoring and evaluation.

Implications of all the available evidence

A crucial challenge for funders and implementers of One Health initiatives has been the weakness of the evidence base needed to indicate what practical steps can be taken to improve their functioning. Our study provides empirical evidence about limitations in stakeholder representation, apparently absent or ambiguous monitoring and evaluation structures, and potential areas of duplication. This information can inform the strategic direction of new and existing OHNs, as well as funders investing in this space.

World Organisation for Animal Health (OIE), the Food and Agriculture Organization (FAO) of the United Nations (UN), the World Bank, and many others.[9] In 2010, the so-called tripartite agreement between WHO, OIE, and FAO was formed with the mandate of "sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interface",[10] with an aim to directly address rabies, zoonotic influenza, and antimicrobial resistance. More recently, WHO have also established a stronger relationship with the UN Environmental Programme, with the joint publication of the biodiversity and human health report,[11] which similarly endorses a One Health approach. One Health has also attracted substantial political attention in discussions at other key high-level political forums in recent years, including the 2016 UN General Assembly, the 2015 G7 Health Minister's Meeting, and the 2016 Commonwealth Health Ministers Meeting. Attention in political spheres has been accompanied by an increase in international funding for One Health from philanthropic, unilateral, bilateral, and multilateral funders.[12,13]

As political and financial support have grown, an increase in One Health-related activities has occurred, with actors from public, private, academic, and non-profit sectors uniting to organise and facilitate multidisciplinary collaborations at the global, regional, and national levels. Many countries across the globe have instituted national One Health programmes of work, including Canada, Kenya, Bangladesh, Rwanda, Pakistan, and India.[14–18]

Regional One Health platforms have also been established in areas such as east Africa, the Middle East, south Asia, and Europe.[19–21]

Although some initial work towards this has been done,[1,22,23] the range of One Health networks (OHNs) operating globally has not yet been documented in a systematic and comprehensive way. Diverse stakeholders including doctors, veterinary professionals, environmentalists, and researchers have expressed concerns about the lack of coordination and possible resultant inefficiencies resulting from duplication.[24,25] Duplication, in this context, can be defined as multiplication of the efforts required to reach the same objective due to parallel, poorly coordinated activities or systems.[26] Although some OHNs coordinate activities and stakeholders well within their own network and make information about their work freely available, the rapid growth of OHNs in numerous countries and regions has made coordination to optimise the collective functioning of individual OHNs challenging.[9]

In view of the scarcity of information on the growing global One Health activities and the need for coordination and communication between initiatives to support efficient use of resources, this study systematically identifies OHNs and seeks to ascertain whether duplication of efforts is occurring across networks, which stakeholders are being engaged, and how frequently monitoring and evaluation of investments is being reported.

Methods

Search strategy and selection criteria

Because our aim was to systematically identify and analyse OHNs, rather than specific scientific literature, we adapted the widely applied systematic scoping review method originally developed by Arksey and O'Malley.[27] An OHN was defined as an engagement between two or more discrete organisations or government entities with at least two of the following sectors represented: animal health, human health, and environment or ecosystem.

Given the absence of standardised terminology around One Health, we dedicated considerable attention to composing our search terms. A cross-disciplinary team

	Search strategy
PubMed	June 26, 2007, to June 25, 2017 (past 10 years)
Google Scholar	First 100 links retrieved using terms from PubMed search
Google	First 100 links retrieved using terms from PubMed search; first 100 links retrieved using terms from PubMed search and additionally including Asia, Africa, or Europe individually; first ten links retrieved using terms from PubMed search and additionally including each country name in Asia (n=50) and in Africa (n=60) individually
Conferences	2nd Global Conference on One Health; Afrique One—A One Health Commission; Biennial Congresses of the International Association for Ecology and HealthFirst; International OCHEA One Health Conference; FVE-CPME One Health Conference; International One Health Congress; One Health for the Real World: zoonoses, ecosystems and wellbeing; One Health Global Risk Forum Davos; One Health Inter-Regional European Conference; West African regional Conference on One Health; WVA–WMA Global Conference on One Health

OCHEA=One Health Central and Eastern Africa. FVE=Federation of Veterinarians of Europe. CPME=Standing Committee of European Doctors. WVA= World Veterinary Association. WMA=World Medical Association.

Table 1: Sources searched to identify potential One Health networks

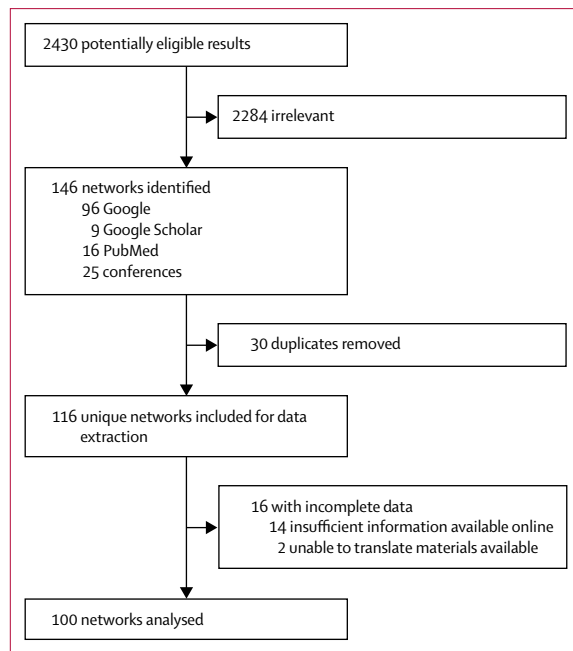|	Definition
Geographical scope	Regions in which networks reported activities
Sectors	
Human	Direct engagement in human health activities
Animal	Direct engagement in animal health activities
Environment and ecosystem	Direct engagement in activities related to the environment and ecosystems
Activities	
Surveillance and monitoring	The process of systematically collecting, consolidating, analysing, and evaluating pertinent data, as well as disseminating results to relevant actors[30]
Disease control	The reduction in incidence, prevalence, morbidity, and mortality of infectious diseases to a locally acceptable level[31]
Emergencies	An occurrence or imminent threat of illness, or adverse health condition, resulting from bioterrorism, epidemic or pandemic disease, or natural disaster[32]
Recovery	Decisions and actions taken post-disaster that aim to restore or improve living conditions of the affected community, while making the necessary adjustments to reduce disaster risk[32]
Research and development	Undertaking activities that endeavour to achieve advances in science or technology, including new tools or medicines[33]
Implementation research	Scientific inquiry to address concerns regarding the implementation of health interventions; working within and for real-world conditions is a key principle of implementation research[34]
Policy development	Development of a vision, a position statement, guidelines or plans to achieve specific goals within a society[35]
Advocacy	Taking action to represent the interests of One Health and to obtain necessary resources[36]
Capacity building	The development and strengthening of human resources and institutional systems[37]
Communication or collaboration platform	A space, physical or otherwise, where stakeholders can convene to share and exchange ideas and information, or work together on common goals and objectives
Data and information sharing	The (routine) exchange of health-related information and situational awareness data amongst involved parties[38]
Community engagement	The process of working in a collaborative manner with communities to address issues that affect their well-being;[39] a community can be defined as a group of individuals who share social characteristics and perspectives[40]
Disbursement of funds	Activities involving the distribution of donations from external funders
Stakeholders	
Government	Government bodies including ministries, departments, and agencies operating at the national or sub-national level
Academic	Universities and other institutions of higher education
Private sector	For-profit businesses
Communities	Members of the population directly served by network activities
Non-governmental organisations	Not-for-profit private organisations engaged at the local, national, regional, or international level[41]

Table 2: Definitions used to classify One Health networks

collectively agreed on an initial set of search terms. Different combinations of search terms were tested by screening the first 50 papers in PubMed to exclude words or phrases that were not useful in yielding network names (a term that yielded fewer than 5 OHNs out of 50 results was excluded). The final search terms used in PubMed were ("One Health" OR "EcoHealth" OR "Planetary Health" OR "One Medicine" OR "emerging infectious diseases" OR "zoonotic diseases") AND ("network" OR "collaboration" OR "movement" OR "platform" OR "consortium" OR "alliance" OR "partnership" OR "hub"). We adapted the PubMed search terms for additional searches in Google, Google Scholar, and key One Health conferences for OHNs, as summarised in table 1. We did our searches between June 5 and Sept 29 2017. No language

Figure 1: Network selection

See **Online** for appendix 1

Figure 2: One Health networks initiated per year since 2000
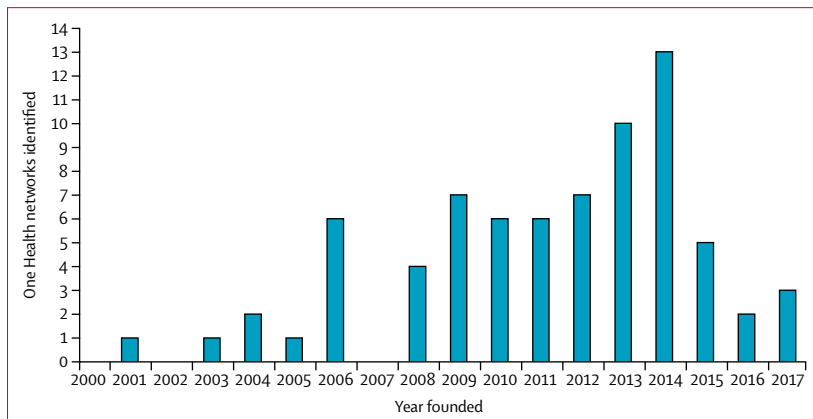80 networks provided information on their year of initiation, of which 74 were formed since 2000.

restrictions were applied, but we were only able to translate from English and French.

To allow for a comprehensive but feasible search, we did one search without any country or region names to capture any networks operating around the world and a further set of targeted searches focusing on the two most populous regions in the developing world: Asia and Africa.[28] We also searched for OHNs in Europe, where the research team and research funders are based, to enable an analysis of connections between regions. The targeted searches for regional and country-specific networks were done in Google as follows: we first included region names (Asia, Africa, and Europe), which we added individually to the original Google search based on the PubMed terms; following this, we did 110 searches by adding each country name in Asia (n=50) and Africa (n=60)—as defined in the regional classification of the United Nations Statistics Division[29]—individually to the search terms detailed.

To identify potential OHNs within the search results, the research team screened each document and website; names of potential OHNs identified were then compiled and duplicates were removed. Subsequently, an eligibility assessment was done by analysing publicly available online materials. Predetermined inclusion criteria were applied to ensure that the organisations identified met our minimum definition of an OHN. Organisations were excluded if they did not include at least two different organisations or government entities and stakeholders or activities across at least two of the following sectors: animal health, human health, and the environment or ecosystem. The eligibility assessment was done independently by two researchers (JS and PR-O). Any disagreements were resolved through an additional independent review by two further researchers (MSK and MS).

Data extraction and analysis

A data extraction template was collectively designed for clear categorisation and analysis of networks by a team of One Health researchers with specific expertise in human health, veterinary medicine, epidemiology, and social sciences. An example is presented in appendix 1. The team defined categories to allow OHNs to be classified in terms of sectors, activities, and stakeholders involved. An initial list of activities and stakeholders was defined through discussion, followed by a pilot phase in which ten networks were classified independently by two researchers (PR-O and JS) to check that the categories were comprehensive and mutually exclusive. Additional stakeholders or activities identified were added after the pilot phase to finalise the data extraction template. Key definitions used for categorising networks are shown in table 2.

The standardised template was used to extract data from all eligible networks. In cases where complete information was not available, because of insufficient details being available from online materials, or language

	Frequency (n=100)
Identity	
Identified as One Health only	71%
Identified as One Health and EcoHealth	7%
Identified as Ecohealth only	4%
Identified as planetary health only	1%
Identified as One Medicine only	1%
Did not use any of the listed terms	16%
Used one or more of listed terms and provided definition	39%
Used listed terms but did not define	45%
Region*	
Asia only	30%
Africa only	24%
Global	19%
Europe only	10%
Other	10%
Asia and Africa	4%
Asia, Africa, and EU	2%
Africa and EU	1%
Asia and EU	0%
Sector	
Human-animal	31%
Human-environment	3%
Animal-environment	2%
All three sectors	64%
Activities	
Communication and collaboration	85%
Data and information sharing	79%
Capacity building	72%
Surveillance and monitoring	45%
Research and development	44%
Advocacy	34%
Disease control	26%
Policy development	18%
Social research and implementation	13%
Community engagement	12%
Disbursement of funds	10%
Risk management and emergencies	5%
Recovery	2%
(Table 3 continues in next column)	

	Frequency (n=100)
(Continued from previous column)	
Transparency	
Clearly defined vision or mission or aims or objectives	77%
Reported named funders	76%
Clearly stated goals or projected outputs	50%
Monitoring and evaluation strategy referred to on website	15%
Stakeholders	
Government	78%
Academic	76%
Non-governmental organisations	54%
Private sector	23%
Communities	10%

Since n=100, percentages are identical to frequencies. EU=European Union.
*Global was defined as networks operating in two or more regions that cannot be categorised into the regional groupings of Asia and Africa, Asia and EU, Africa and EU, and Asia, Africa, and EU; other was defined as networks exclusively operating outside of Asia, Africa, and Europe.

***Table 3:* Characteristics of networks analysed**

Results

From 2430 search results, we identified 116 unique OHNs (figure 1). Because of a lack of publicly-available information (n=14) and translation limitations (n=2) we were unable to populate the data extraction template for 16 OHNs, leaving 100 OHNs for inclusion in the final analysis (appendix 2). We found information on the year of initiation for 80 OHNs, most of which (69 [86%]) were formed after 2005. There were spikes in the number of new OHNs initiated in 2013 and 2014 (figure 2).

Table 3 shows the characteristics of the OHNs identified. Most networks (78% of 100) used the term One Health to identify their approach, although other terms such as EcoHealth (4%), planetary health (1%), and One Medicine (1%) were also used to denote multi-disciplinary activities relating to human health, animal health, and the environment or ecosystem. 7% of networks referenced their work as relevant to both One Health and EcoHealth. Despite participating in activities across the One Health spectrum, 16% of networks did not identify themselves with any of these terms. Given that there is no universally accepted definition for One Health, we investigated whether networks defined key terms. Of the 84% OHNs that used one or more of the terms (One Health, EcoHealth, planetary health, or One Medicine), more than half (45 [54%]) did not present a definition or description of the approach. Examples of definitions that are most representative of those used on OHN websites are presented in panel 1.

Most OHNs (64%) operated nationally or regionally, but not across regions: 30% exclusively operated in Asia, 24% in Africa, and 10% in Europe (figure 3). Only 2% of OHNs operated across all three regions of focus. Furthermore, there were few collaborations within the developing world

See **Online** for appendix 2

barriers (ie, materials published in a language other than English or French), the OHN was recorded as incomplete. These networks were captured as part of the universe of existing OHNs but were not included in the analysis (figure 1). Data were analysed descriptively and are presented in tables and charts.

Role of the funding source

part of the scope of their work. Capacity building of human resources for One Health was also common (72%). By contrast, less than 20% were involved in activities such as policy development, community engagement, emergencies, and post-emergency recovery (table 3). Network research objectives were dominated by the development of new tools, including diagnostics, vaccines, and other pharmaceuticals (44%), with only 13% doing research to guide implementation in countries and communities in receipt of these products. Despite reporting a range of activities, only half of OHNs clearly stated their goals or expected outputs in publicly available material. Furthermore, only 15% presented a strategy for monitoring and evaluating outputs from their activities in publicly available materials. By contrast, most OHNs (76%) made information about funding support readily available.

Our analysis of stakeholders reported to be involved in OHN activities highlighted the under-representation of specific groups. Academic institutions and government bodies were involved in most of the OHNs analysed; 78% of OHNs involved academics and 78% involved government bodies. Non-governmental organisations (NGOs) were represented in 54% of OHNs. By contrast, private for-profit organisations were only involved in 23% of OHNs and members of communities affected by the work of OHNs were represented in 10%. Only 3% of networks had engagement from all five of these stakeholder groups. Further analysis to ascertain which combinations of stakeholders most frequently work together showed that the most common collaborations were between government bodies and academics (22%) and government bodies, academics, and NGOs (22%). Of the 23 networks that engaged for-profit organisations, 18 involved government bodies and 14 involved academic stakeholders (with or without additional stakeholder groups engaged). OHNs rarely named the for-profit organisation engaged and instead frequently only reported that private sector, for-profit companies were involved. Types of for-profit organisations that we were able to identify in information shared by OHNs included pharmaceutical, biotechnology, and information technology companies. Panel 2 shows examples of three networks included in our analysis.

(ie, Asia-Africa collaborations): 14 networks reported work in both Asia and Africa, of which 13 were headquartered in the USA or Europe. Only four of the 14 OHNs operating in both Asia and Africa were exclusively focused on these regions. Of these four, two fall under the Emerging Pandemic Threats 2 Program initiated by the US Agency for International Development[46] and one is the Participatory Epidemiology Network for Animal and Public Health network,[47] which is based out of Tufts Cummings School of Veterinary Medicine in the USA. The only OHN operating exclusively in Asia and Africa that was not headquartered in the USA or Europe is the International Livestock Research Institute (ILRI) based in Kenya.[48] The ILRI is a member of the Consultative Group on International Agricultural Research global consortium, which consists of 15 centres.[49]

64% of OHNs reported activities across all three One Health sectors: animal, human, and environment. The remaining networks reported engagement with only two of the three sectors: human and animal (31%), human and environment (3%), and animal and environment (2%). Thus, about a third of OHNs did not report any activities related to the external environment and its effects on human or animal health.

OHNs were involved in a wide range of diverse activities, but with notable concentration on certain activities, with others less frequently covered. Overall, minimal information was provided about the focus or remit of activities, including details about disease areas covered. The most common activity of OHNs was to facilitate communication and collaboration through arranging in-person or virtual meetings (85%). Similarly, 79% of OHNs reported data and information sharing as

Discussion

In view of the increase in political and financial commitments to address the relationship between human health, the health of animals, and the state of natural systems in which humans and animals exist,[24] our study is the first, to our knowledge, to systematically address gaps in information about networks engaged in work across the One Health spectrum. Our aim was to analyse how OHNs are operating as a collective group rather than comment on the functioning of individual initiatives. To this end, we identified specific gaps in the coverage of activities, limitations in stakeholder representation,
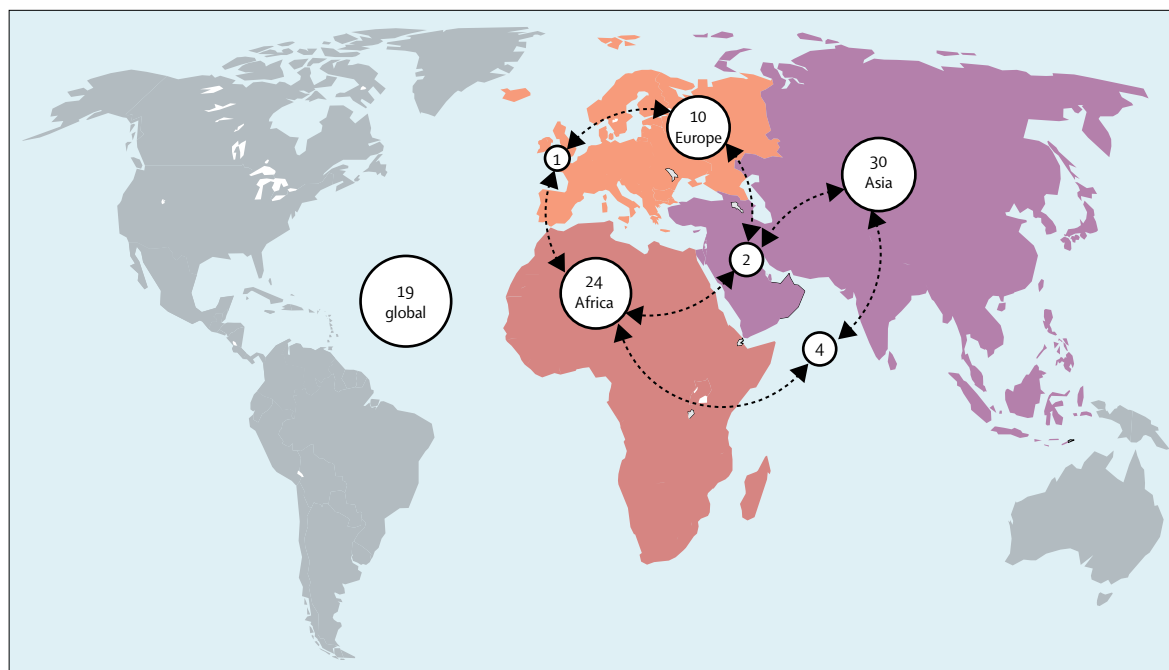
Figure 3: Regional distribution and connectivity of One Health networks

apparently absent or ambiguous accountability structures, and potential areas of duplication.

A key finding was that although most OHNs (64%) engaged with all three sectors, nearly a third (31%) did not list the environment or ecosystem as an area of concern or network focus. This finding provides evidence to support the assertion that there is a gap in the scope of One Health initiatives with respect to engagement with the environment, which has also been shown in terms of authorship of articles on One Health.[1] Our analysis further revealed that activities such as communication and collaboration, data and information sharing, and human resource capacity building were reported by OHNs far more often than were other activities, such as community engagement and education or implementation research. It might be valuable to assess whether the large number of OHNs working on communication and data-sharing platforms are duplicating efforts and whether they could be better coordinated to improve efficiency. With a view to community level impact of ongoing investments in One Health, engagement with target populations and research to aid adaptation of interventions to the local context is crucial to success;[53,54] our study documents for the first time that these activities are being done by less than 15% of OHNs. Similarly, in examining stakeholder involvement within OHNs, academic institutions, NGOs, and government bodies predominated, whereas community representatives and for-profit organisations were rarely represented.

Other researchers have commented on the absence of a clear agenda or normative understanding of the optimal

Panel 2: **Examples of networks included in analyses**

One Health Commission (OHC)
The Charter of this global network is to "…'Educate' and 'Create' networks to improve health outcomes and well-being of humans, animals and plants and to promote environmental resilience through a collaborative, global One Health approach".[50]

One Health Central and Eastern Africa (OHCEA)
The mission of OHCEA is "To drive transformational change for continuous improvement of health and well being of humans, animals and ecosystems through multi-displinary research, training and community service."[51]

One Health Network South East Asia (OHSEA)
The OHSEA is primarily a collaborative platform that is active in Asia. Their objective is to "extend this platform to other projects in the South East Asia region, which share the same focus on One Health issues, to improve surveillance, strengthen synergies, increase collaboration between research projects".[52]

functioning of global OHNs as a group;[24] given this situation, determining what would constitute improvements is challenging.[1] One approach to overcoming these challenges, led by the Network for the Evaluation of One Health, is the application of systems theory to evaluate One Health initiatives that operate within a context that is inherently complex and dynamic.[55,56] Although we identified clear gaps in terms of OHNs'

reporting of monitoring and evaluation strategies and activities covered, we acknowledge that the operations of OHNs (and the tools to evaluate these operations) are still developing and seek to provide an evidence base to guide their evolution. Indeed, challenges in the coordination of stakeholders, goals, and activities are not uncommon when there is a burst of attention to a public health issue, particularly when the attention is from funders.[57] For example, the initial response to the HIV/AIDS epidemic has been criticised for having multiple overlapping responses, which might not reflect local community priorities.[58,59] Our finding that research activities are being skewed towards surveillance and monitoring and the development of new products, as compared with studies that inform implementation in low-income and middle-income countries or policy development, is also found in other areas, such as tuberculosis control.[60] Examples from outside of disease control also exist, such as the failure of the UN Climate Summit in Copenhagen to come to a legal consensus, which has been attributed to insufficient engagement of all essential stakeholders.[61] Concomitant with a spike in interest in a particular topic, it is not uncommon to find suboptimal strategic planning, coordination, and stakeholder engagement. It is therefore crucial that OHNs move away from modes of action based on "a scramble for attention and funds" that "[marginalises] more complex drivers of disease such as ecosystem change and socio-political dynamics".[1]

The data generated by our systematic search and analysis of OHNs provides an evidence base for funders, facilitators, and managers of OHNs to critically reflect on how to develop future strategies that are in line with the needs of the regions and communities they serve. Recognising that our views about the optimal mix of activities or stakeholder representation for OHNs might be shaped by internal biases, including a possible anthropocentric approach that places more value on humans than animals, ecological systems, and biodiversity, we have selectively made recommendations. A clear finding on which we can base suggestions for urgent changes and an evolution of practices is the scarcity of easily accessible information on OHN goals, focus area of activities (eg, communicable disease, non-communicable disease, climate change, food security), and how activities will be monitored or evaluated. For example, although most OHNs (85%) stated that they were involved in communication-related activities, information about the nature of engagement in terms of who was communicating with whom or the expected impact of the communication were rarely provided on websites. Similarly, 45% of networks listed surveillance and monitoring among their activities, but few detailed their methods or outputs. Although OHNs might be conducting monitoring and evaluation in line with donor requirements, only 15% made information about their strategy to do so readily available online; our study raises important questions about the likely impact of ongoing One Health activities and how this will be assessed. As

reported by Baum and colleagues,[62] there seems to be little emphasis on the evaluation of One Health approaches because effectiveness is assumed without supporting evidence.[62]

We acknowledge that changes to the current OHN landscape will be accompanied by challenges. These challenges include competition for scarce resources, the lack absence of an overarching authority, donor-driven, disease-specific programmes, poorly defined measures of impact, and conflicting agendas of diverse stakeholders.[1,9,62,63] However, changes such as the development of more robust and transparent monitoring and evaluation strategies, wider engagement of under-represented stakeholders in the leadership of OHNs, and a more systems-thinking approach that is inclusive of environment and ecosystem factors might be warranted on the basis of our analysis of current gaps in the functioning of OHNs.

Our findings should be viewed in light of limitations in our scope and methods. Because of the large number of OHNs identified and the scarcity of information about the owners of several networks, we relied on information made publicly available online by OHNs and were not able to verify or obtain additional information by contacting network representatives. Further studies to understand leadership structures and power dynamics between stakeholders and countries that comprise regional OHNs, as well as analyses of network areas of focus (eg, food security or zoonoses) could offer important insights. For example, it would be useful to know whether specific diseases or disease areas such as rabies, highly pathogenic avian influenza, Ebola virus disease, or antimicrobial resistance are attracting more OHN attention than are non-communicable diseases and food security. When we attempted to undertake a more detailed analysis of OHN areas of focus, we found that information presented in publicly available materials was incomplete, vague, or inconsistently reported (some OHNs mentioned specific diseases while others mentioned zoonoses or infectious diseases generally). Therefore, such an analysis would require additional primary data collection and will be the topic of a follow-up paper. We also acknowledge that our scope was primarily restricted to OHNs presenting information in English or French and operating in Asia, Africa, or Europe. Nonetheless, our methods, including our search terms, can be used by other researchers to analyse OHNs in different regions.

Along with increased political attention and investments in One Health—as illustrated by the growth in OHNs that we documented since 2005—there are concerns about a lack of strategic direction, coordination, and true operationalisation of One Health principles.[9,64,65] A crucial challenge has been a weak evidence base to suggest what practical steps can be taken by OHNs to improve their functioning. Although there is no normative definition of how to best operationalise a One Health approach, our study provides empirical evidence

of gaps in terms of types of activities, addressing the linkages between the natural environment and human and animal health, involvement of stakeholders from the community and for-profit sector, collaborations driven by developing countries, and reporting of goals and monitoring plans. This information can inform the strategic direction of new and existing OHNs, as well as funders investing in this space. Having seen that duplication, low community engagement, ineffective knowledge sharing, and poor monitoring and evaluation can reduce the impact and sustainability of new initiatives, it is imperative to avoid such a situation in the growing portfolio of One Health work.

References
1 Galaz V, Leach M, Scoones I, Stein C. The political economy of One Health research and policy. STEPS working paper 81. Brighton: STEPS Centre, 2015.
2 Häsler B, Benfield C, Kock R. One Health: an emerging interdisciplinary approach. 2017. https://www.immunology.org/publications/immunology-news/immunology-news-march-2017/one-health-emerging-interdisciplinary (accessed Jan 16, 2018).
3 Zezza A, Tasciotti L. Urban agriculture, poverty, and food security: empirical evidence from a sample of developing countries. *Food Policy* 2010; **35**: 265–73.
4 Chan M. WHO Director-General addresses G7 health ministers meeting on antimicrobial resistance. 2015. http://who.int/dg/speeches/2015/g7-ebola-lessons-learned/en/.
5 Atlas RM. One Health: its origins and future. In: Mackenzie JS, Jeggo M, Daszak P, Richt JA, eds. One Health: the human-animal-environment interfaces in emerging infectious diseases. Berlin: Springer, 2013: 1–13.
6 Zinsstag J, Mackenzie JS, Jeggo M, Heymann DL, Patz JA, Daszak P. Mainstreaming one health. *Ecohealth* 2012; **9**: 107–10.
7 Choi BCK, Pak AWP. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clin Investig Med* 2006; **29**: 351–64.
8 Mwangi W, de Figueiredo P, Criscitiello MF. One Health: addressing global challenges at the nexus of human, animal, and environmental health. *PLoS Pathog* 2016; **12**: e1005731.
9 Lee K, Brumme ZL. Operationalizing the One Health approach: the global governance challenges. *Health Policy Plan* 2013; **28**: 778–85.
10 World Health Organization, Food and Agriculture Organization, World Organization for Animal Health. High-level technical meeting to address health risks at the human-animal ecosystems interfaces. Mexico city, Mexico. 15–17 November 2011. 2012. http://www.fao.org/docrep/017/i3119e/i3119e.pdf.
11 WHO, Secretariat of the Convention on Biological Diversity. Connecting global priorities: biodiversity and human health. A state of knowledge review. 2015. http://apps.who.int/iris/bitstream/10665/174012/1/9789241508537_eng.pdf?ua=1 (accessed Dec 22, 2017).
12 MacPherson N, Marie Kimball A, Burke C, Abernethy N, Tempongko S, Zinsstag J. Key findings and lessons from an evaluation of the Rockefeller Foundation's Disease Surveillance Networks Initiative. *Emerg Health Threats J* 2013; **6**: 19959.
13 Kelly TR, Karesh WB, Johnson CK, et al. One Health proof of concept: Bringing a transdisciplinary approach to surveillance for zoonotic viruses at the human-wild animal interface. *Prev Vet Med* 2017; **137**: 112–18.
14 Parmley J, Leung Z, Léger D, et al. One health and food safety—the Canadian experience: a holistic approach toward enteric bacterial pathogens and antimicrobial resistance surveillance. Washington, DC: National Acadamies Press, 2012.
15 Mbabu M, Njeru I, File S, et al. Establishing a one health office in Kenya. *Pan Afr Med J* 2014; **19**: 106.
16 Public Health Foundation of India. An Introduction to the Roadmap to Combat Zoonoses in India Initiative. http://zoonoses.phfi.org/pdf/RCZI_Brochure.pdf (accessed Oct 24, 2017).
17 Pak One Health Alliance. Welcome to Pak One Health Alliance. 2017. http://www.pakonehealth.org/index.php (accessed Oct 27, 2017).
18 Institute of Epidemiology Disease Control and Research. Strategic framework for One Health approach to infectious diseases in Bangladesh. 2012. http://www.iedcr.gov.bd/pdf/files/One Health/Strategic_framework_for_One_Health_Bangladesh-26 Jan.pdf (accessed Jan 18, 2018).
19 Connecting Organizations for Regional Disease Surveillance. Connecting Organizations for Regional Disease Surveillance. https://www.cordsnetwork.org/ (accessed Oct 24, 2017).
20 GREASE. Management of emerging risks in southeast Asia. https://www.grease-network.org (accessed Jan 18, 2018).
21 Centers for Disease Control and Prevention. One Health Program: South Africa Regional Global Disaster Detection Center. 2015. https://www.cdc.gov/globalhealth/countries/southafrica/what/one_health.htm (accessed Jan 18, 2018).
22 Hueston W, Appert J, Denny T, King L, Umber J, Valeri L. Assessing global adoption of one health approaches. *Ecohealth* 2013; **10**: 228–33.
23 Hall D, Coghlan B. Implementation of the One Health approach in Asia & Europe: how to set-up a common basis for action and exchange of experience. September, 2011. http://studylib.net/doc/13771324/asia%E2%80%93europe-meeting--implementation-of-the-one-health-app (accessed Dec 22, 2017).
24 Gibbs EPJ. The evolution of One Health: a decade of progress and challenges for the future. *Vet Rec* 2014; **174**: 85–91.
25 Valeix S. Towards One Health? Evolution of international collaboration networks on Nipah virus research from 1999–2011. STEPS working paper 74. Brighton: STEPS Centre, 2014.
26 Marchal B, Cavalli A, Kegels G. Global health actors claim to support health system strengthening—is this reality or rhetoric? *PLoS Med* 2009; **6**: e1000059.
27 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005; **8**: 19–32.
28 United Nations DESA/Population Division. World population prospects 2017. 2017. https://esa.un.org/unpd/wpp/ (accessed Jan 16, 2018).
29 United Nations Statistics Division. Methodology: countries or areas/geographical regions. 2017. https://unstats.un.org/unsd/methodology/m49/ (accessed Jan 18, 2018).
30 Heymann DL. Control of communicable diseases manual, 19th edn. Washington, DC: American Public Health Association, 2008.
31 Heymann D. Control, elimination, eradication and re-emergence of infectious diseases: getting the message right. World Health Organization, 2011. http://www.who.int/bulletin/volumes/84/2/editorial10206html/en/ (accessed Dec 22, 2017).
32 WHO. Definitions: emergencies. 2014. http://www.who.int/hac/about/definitions/en/ (accessed Dec 22, 2017).
33 UK Department of Business Innovation and Skills. Guidelines on the meaning of research and development for tax purposes 5. 2010. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/71260/bis-10-1393-rd-tax-purposes.pdf (accessed Dec 22, 2017).
34 Peters DH, Adam T, Alonge O, Agyepong IA, Tran N. Implementation research: what it is and how to do it. *BMJ* 2014; **347**: f6753.
35 WHO. Health policy. http://www.who.int/topics/health_policy/en/ (accessed Jan 16, 2018).
36 Advocacy Quality Performance Mark. Code of practice. 2014 http://www.qualityadvocacy.org.uk/wp-content/uploads/2014/03/Code-of-Practice.pdf (accessed Dec 22, 2017).
37 WHO. Capacity building and initiatives. 2013. http://www.who.int/tobacco/control/capacity_building/background/en/ (accessed Dec 22, 2017).

38 Centers for Disease Control and Prevention. Public health preparedness capabilities: national standards for state and local planning. Capability 6: information sharing. 2011. https://www.cdc.gov/phpr/readiness/00_docs/capability6.pdf (accessed Dec 22, 2017).

39 WHO. Community engagement in tuberculosis. 2013. http://www.who.int/tb/publications/Community_Engagement_factsheet_2014corr_29may15.pdf?ua=1 (accessed Dec 22, 2017).

40 MacQueen KM, McLellan E, Metzger DS, et al. What is community? An evidence-based definition for participatory public health. Am J Public Health 2001; 91: 1929–38.

41 World Bank. Working with NGOs. 1995. http://documents.worldbank.org/curated/en/814581468739240860/pdf/multi-page.pdf (accessed Dec 22, 2017).

42 CTPH. Conservation Through Public Health. http://www.ctph.org/one-health/ (accessed Oct 25, 2017).

43 FBLI. Field Building Leadership Initiative. http://www.ecohealthasia.net/about-us/faqs.html#what-is-ecohealth (accessed Oct 25, 2017).

44 Planetary Health Alliance. Planetary Health Alliance. https://planetaryhealthalliance.org/planetary-health (accessed Jan 16, 2018).

45 Humanimal Trust. Humanimal Trust. http://www.humanimaltrust.org.uk/what-is-one-medicine/ (accessed Oct 26, 2017).

46 USAID. Preparedness and response. 2017. http://preparednessandresponse.org/ (accessed Jan 16, 2018).

47 Participatory Epidemiology Network for Animal and Public Health. 2017. https://penaph.net (accessed Dec 19, 2017).

48 IRLRI. International Livestock Research Institute. https://www.ilri.org (accessed Jan 16, 2018).

49 CGIAR. Consultative Group on International Agricultural Research. http://www.cgiar.org (accessed Jan 16, 2018).

50 OHC. One Health Commission. https://www.onehealthcommission.org/ (accessed Jan 16, 2018).

51 OHCEA. One Health Central and Eastern Africa. http://ohcea.org/index.php?option=com_content&view=article&id=31&Itemid=102 (accessed Jan 16, 2018).

52 OHSEA. One Health Network South East Asia. http://www.onehealthsea.org/ohsea/our-network (accessed Jan 16, 2018).

53 Binot A, Duboz R, Promburom P, et al. A framework to promote collective action within the One Health community of practice: using participatory modelling to enable interdisciplinary, cross-sectoral and multi-level integration. One Health 2015; 1: 44–48.

54 Mazet JAK, Uhart MM, Keyyu JD. Stakeholders in one health. Rev Sci Tech 2014; 33: 443–52.

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

56 Queenan K, Garnier J, Rosenbaum Nielsen L, et al. Roadmap to a One Health agenda 2030. Perspect Agric Vet Sci Nutr Nat Resour 2017; 12: 1–17.

57 Frenk J, Moon S. Governance challenges in global health. N Engl J Med 2013; 368: 936–42.

58 Gostin LO, Mok EA. Grand challenges in global health governance. Br Med Bull 2009; 90: 7–18.

59 Osewe PL. One national response: synergy networks for effective HIV education among government agencies, nongovernmental organizations, and development partners. Prospects 2009; 39: 399–412.

60 Khan MS, Fletcher H, Coker R. Investments in tuberculosis research–what are the gaps? BMC Med 2016; 14: 123.

61 Fisher DR. COP-15 in Copenhagen: how the merging of movements left civil society out in the cold. Glob Environ Polit 2010; 10: 11–17.

62 Baum SE, Machalaba C, Daszak P, Salerno RH, Karesh WB. Evaluating one health: are we demonstrating effectiveness? One Health 2017; 3: 5–10.

63 Rushton J, Häsler B, De Haan N, Rushton R. Economic benefits or drivers of a 'One Health' approach: why should anyone invest? Onderstepoort J Vet Res 2012; 79: 75–79.

64 McKenzie JS, Dahal R, Kakkar M, et al. One Health research and training and government support for One Health in south Asia. Infect Ecol Epidemiol 2016; 6: 33842.

65 Cunningham AA, Scoones I, Wood JLN. One Health for a changing world: new perspectives from Africa. Philos Trans R Soc B Biol Sci 2017; 372: 20160162.