



Future directions for One Health research: Regional and sectoral gaps

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ABSTRACT

Implementation of a One Health approach varies considerably between different geographical regions and remains challenging to implement without greater inclusivity of different disciplinary capacity and expertise. We performed comparative analyses of abstracts presented at the 1st World One Health Congress (WOHC 2011) and 6th WOHC (2020) to explore and describe the evolving demographics and disciplinary scope of One Health research. We classified abstracts into six One Health research categories and twenty-three subcategories. We also recorded corresponding authors' country and regional affiliation as well as study country (i.e., the country in which the research was conducted) to explore potential asymmetries between funding recipients and study subjects. The WOHC has seen a significant expansion in participation over the last 10 years. The numbers of abstracts accepted to the Congress increased threefold over the last decade (i.e., 302 abstracts in 2010, and 932 abstracts in 2020). At both Congresses, "Disease Surveillance" accounted for the largest proportion (105/302 (35%) and 335/932 (36%) in 2010 and 2020, respectively) of all abstracts accepted. However, "Environmental and Ecological Issues" (33/302 (10%) and 94/932 (11%)), and "Sustainable Food Systems" (19/302 (6%) and 44/932 (4%)) were less well-represented categories of One Health research in both 1st and 6th WOHC respectively. In contrast, "Antimicrobial Resistance" related research increased substantially over time (4/302 (1%) in 2011) and (119/932 (13%) in 2020). There were also differences in the type of research by authors based in "Very High Human Development" index countries compared to "Medium and Low Human Development. "Public Policy" dominated the former, whereas "Disease Surveillance" dominated the latter, suggesting potential regional differences regarding One Health research priorities. The results of the study highlight potential regional gaps and differences in One Health research priorities, with respect to emphasis on operational (surveillance) versus strategic (policy) One Health activities.

1. Introduction

The concept of One Health highlights the important inter-relationships between health and well-being of people, animals, plants, and the environment which supports their existence [1]. One Health has been recently redefined in November 2021 by the One Health High Level Expert Panel (OHHLEP). The new definition stresses an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems [2]. It takes a wider view of health, which extends to include clean air, water, energy and safe and nutritious food and which is aligned with the broad principles set out in the Sustainable Development Goals (SDGs) [3].

One Health gained traction as a framework for disease outbreak preparedness, after a series of zoonotic disease events (e.g., Severe Acute Respiratory Syndrome (SARS), Ebola and H1N1 influenza) which involved wildlife reservoirs [4]. The Manhattan Principles were formulated to address existential threats to "life on earth" [5]. These 12 recommendations advocated for a sustainable systems approach to avoid and prevent epidemic or epizootic diseases which included consideration of the health of wildlife, biodiversity, conservation and eco-systems [5,6]. The Berlin Principles on One Health (which extended the Manhattan Principles), urged positive action, education and participation of indigenous peoples and local communities to address not only ecosystem health and integrity, which has been compromised by rapid

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socioecological changes, but also new challenges posed by antimicrobial resistance (AMR), climate change and biodiversity loss [5]. These emerging challenges require interdisciplinary and multidisciplinary approaches that incorporates holistic expertise, which goes beyond zoonotic infectious disease [3,5,7]. Researchers and policymakers can identify and prioritize leverage points for OH actions by understanding the interactions and overlaps between the SDGs. This will make OH interventions more efficient and sustainable, minimize antagonistic outcomes, and increase benefits explicitly defined [3].

The overall scope and basic definition of One Health is intentionally broad, encompassing many different disciplines and research foci as well as earlier concepts (e.g., One Medicine, translational medicine, comparative medicine, evolutionary medicine) [8–10]. However, while some elements of One Health research have received significant attention (e.g., surveillance for infectious diseases [11] and AMR [9]), other aspects (e.g., conservation of natural resources and climate change) have received less consideration. [12] In this study, we aims to take stock of OH research evolution; by classifying abstracts of presentations from the 1st and 6th World One Health Congress (WOHC) into six One Health categories [13]. We also aimed to document how One Health research, as represented by the congresses, has evolved during the last decade. The congress participants addressed challenges such as the COVID-19, zoonotic diseases, and AMR and the need to bridge the gap between scientists and policymakers for a healthier world.

2. Methodology

WOHCs have emerged in contemporary history as perhaps the most important opportunity for One Health researchers to congregate, and thereby provide a unique opportunity to observe the current direction of One Health and biases [10,12,14,15]. Commonwealth Scientific and Industrial Research Organization (CSIRO) and One Health Platform respectively hosted 1st and 6th WOHCs in Melbourne, Australia, and Edinburgh, United Kingdom respectively [16,17]. WOHCs represent an opportunity not only for congregating OH researchers, but also to provide a glimpse into the One Health current direction. The 6th WOHC attracted greater participation in comparison with the previous WOHCs [16,17,18] It is important to note that the online format changed the acceptance by authors to the invitation to speak but it did not change the process by which abstracts were selected during the 6th WOHC. The online format due to COVID-19 restrictions, allowed researchers around the world, particularly those from Medium and Low Human Development Index countries who may have been precluded from attending in-person congresses in the past by financial constraints, to join and present their work at this prestigious forum [18].

The abstracts were categorized into six broadly recognized research categories of One Health, as identified by WOHCs and One Health stakeholders and policy makers [13]: 1) “Disease Surveillance”; 2) “Capacity Building and Civil Society”; 3) “Public Policy”; 4) “Antimicrobial Resistance”; 5) “Environmental and Ecological Issues”; and 6) “Sustainable Food Systems”. Abstracts related to capacity building and civil society were grouped together due to their inherent similarities and shared focus on societal developments i.e., articles examine civil society strengthening to illuminate issues, challenges, and lessons for One Health capacity building.

Abstracts used for the analyses were obtained online for the 1st WOHC [19] and accessed through personal account by the corresponding author at the time of the 6th WOHC. Abstracts were assigned to the six afore-mentioned categories based on key words in the title and after careful reading of the abstract by the corresponding author. Sub-categorization of abstracts into twenty-three One Health research fields were performed, as proposed by the One Health Commission [20] (Table 1). Category names are marked with a double comma and capitalized to differentiate from subcategories that are marked with a single comma and lowercase. Thematic distribution of abstracts at both conferences proved useful for categorization of abstracts into six board

Table 1
Categories, subcategories, and keywords used for the classification of One Health abstracts.

Categories	Subcategories	Keywords
Disease Surveillance	disease surveillance	serological surveillance, infectious diseases, passive surveillance
	basic and translational research	translational research, fundamental biological, molecular, and chemical research
	occupational health risk	occupational health, occupational biological hazard, occupational safety
	comparative medicine	animal models of human and animal diseases
Civil Society & Capacity Building	communication, outreach, and perception studies	KAP survey, cross sectional survey, outreach studies
	economics, civil society, social sciences	economic / complex systems, civil society, social sciences, sociology
	professional education	training, hands on practice, next generation professionals
	disaster preparedness	risk preparedness, hazard preparedness response
Public Policy and Regulation	human - animal bond	bonding
	clinical medicine needs for interrelationship between health professionals	clinical medicine, research gap, collaboration
	public policy	public policy, regulations, regulatory measures
Antimicrobial Resistance	global trade. Commerce and security	trade, commerce, biological security
	antimicrobial resistance, surveillance, and mitigation	antimicrobial resistance, antimicrobial surveillance, antimicrobial resistance mitigation/ mitigation measures
Sustainable Food Systems	food safety and security	food safety, food security, food crisis
	water safety and security agriculture production and land use	water safety, water security agriculture production, crop production, land use
Ecological and Environmental Issues	animal as sentinels for environmental agents and containments detection and response	environmental hazard, contamination detection, sentinel animals
	environmental health	environmental health, ecohealth
	welfare/well-being of animals, humans, ecosystems, and planet	sustainability, welfare/ well-being
	climate change and its impacts on health of humans, animals, and ecosystem	climate change, impact of climate, global warming
	plant / soil health	plant health, soil health
	biodiversity and conservation medicine	biodiversity, conservation medicine
	natural resources conservation	conservation, natural resources

categories and twenty-three subcategories.

The corresponding author’s institutional, national, and regional affiliations, as well as the country in which the research was conducted, were used to describe the geographical distribution of One Health research funding and location. To determine the distribution of abstracts across countries at different development levels, we used thresholds of the Human Development Index (HDI) in the Human Development Reports (HDRs) 2011 [21] and 2020 [22] by UNDP, to distinguish between Very High Human Development (VHHD) countries (HDI >0.8), High Human Development (HHD) countries (HDI = 0.70–0.79), Medium Human Development (MHD) countries (HDI = 0.55–0.69), and Low Human Development (LHD) countries (HDI < 0.55). We looked for thematic gaps associated with countries in which research was

conducted based on corresponding authors affiliation, study site and international collaboration. Study maps were generated using Microsoft Excel 365® (Microsoft, Seattle, WA, USA). Descriptive analyses, cross tabulation and spearman correlation of the study variables were performed using R and SPSS 28.0 [23]. Detailed distribution of countries along with their presented work at subcategory level were displayed using DT and Leaflet packages in interactive web Shiny App [24].

3. Results

A total of 302 abstracts from 54 countries were presented at the 1st WOHC, while 932 abstracts from 93 countries were presented at the 6th WOHC 2020. It shows the tremendous growth in abstract submissions (68%) and country-wise participation (42%) from the 1st to 6th WOHCs.

3.1. Geographical distribution of One Health research

A graphical description of the distribution of study sites, corresponding authors and international One Health collaboration is presented (Fig. 1).

The location of the WOHC influences participation. The 1st WOHC, which was held in Australia, resulted in a high proportion of corresponding authors from the Australian continent (81 (27%), and North America (74/302 (25%)), followed by Europe (64/302 (21%)), Asia (45/302 (15%)), Africa (45/302 (12%)) and one person from South America (1/302 (0.2%)). In contrast, the 6th WOHC, which was held online, resulted in a greater proportion of corresponding authors from Europe (328/932 (35%)) and Africa (255/932 (27%)), followed by Asia (188/932 (20%), North America (102/932 (11%)), Australia (32/932 (4%)) and South America (27/932 (3%)).

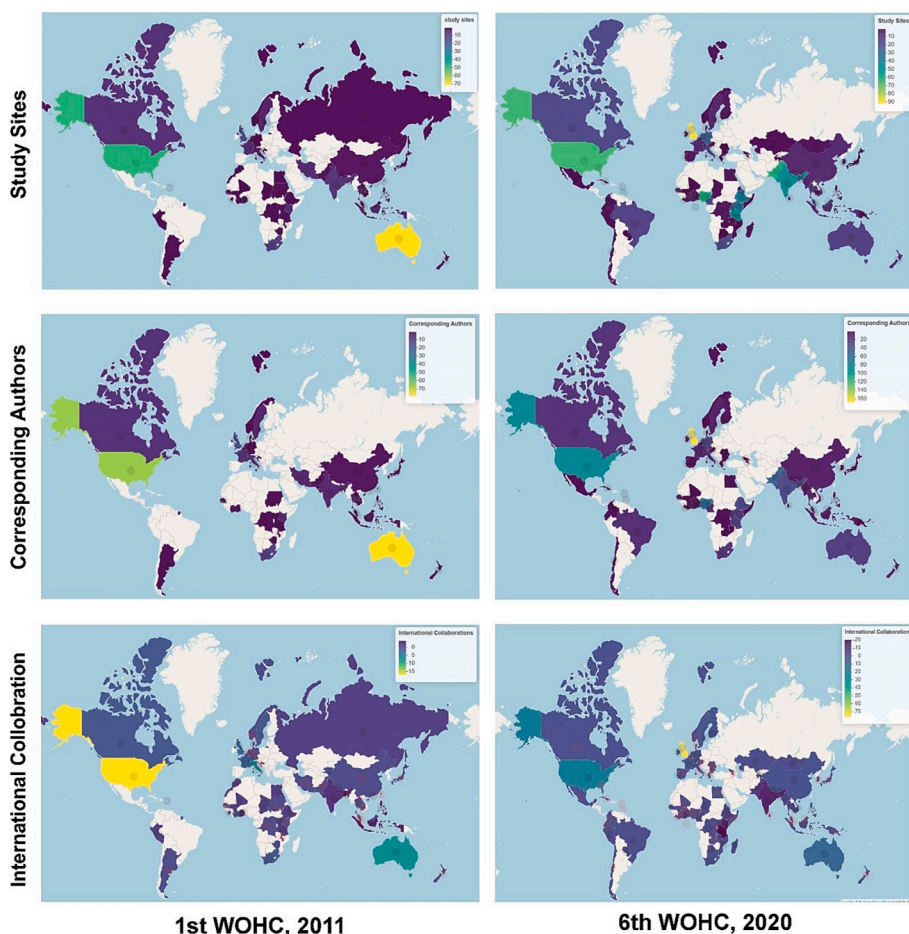


Fig. 1. Comparison of abstract distribution from 1st and 6th World One Health Congress based on study sites (a and d), affiliation of corresponding authors (b and e), and international collaborations (c, f). Contributions to international collaborations was calculated as the difference between the number of studies conducted in the country and the number of corresponding author affiliations from the country. Negative and positive values for (c and f) in interactive web map format <https://batconpakistan.org/our-apps/> indicate sink (received collaboration) and source (extended collaboration) for One Health research respectively. Source countries such as US and UK for the 1st and 6th WOHC are indicated by yellowish green color while sink countries such as India and Pakistan for both Conferences are indicated by dark blue color. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

We found (19/54 (35%)) countries represented at the 1st WOHC were neither sink nor source of OH collaborations in comparison with (45% (38/84)) countries in the 6th WOHC. These countries are different from those that did not submit any abstracts during the conference - as indicated by the grey color (Fig. 1e). Additionally, we identified fourteen studies that originated from Sub-Saharan Africa, however none of these studies had corresponding authors from the region (Fig. 1f).

3.2. Research gaps in One Health research

A description of the distribution of different research themes represented at each Congress is presented (Fig. 2). The priority areas in 1st and 6th WOHC were different: the emphasis in 1st WOHC was on “Public Policy” (58 (19%)), whereas the emphasis in the 6th WOHC was “Disease Surveillance” (212 (23%)). There was limited representation of One Health research in “Environmental and Ecological Issues” which include subcategories such as ‘natural resources’, ‘biodiversity and conservation medicine’ and absolutely no abstract submitted under the subcategory ‘clinical demands for interrelationship between health professions’ (Fig. 2).

During the 1st WOHC, “Disease Surveillance” was the dominant research topic within accepted abstracts from Australia, Europe, Asia, and South America, while “Public Policy” and “Capacity Building and Civil Society” related research were the most common accepted abstracts from North America and Africa respectively (Fig. 3).

In the 6th WOHC, “Disease Surveillance” dominated submissions from Europe, Africa, Asia, and South America, while “Capacity Building & Civil Society”, and “Antimicrobial Resistance” related research work were the most common submissions from North America and Australia respectively (Fig. 3). “Antimicrobial Resistance” research was not a

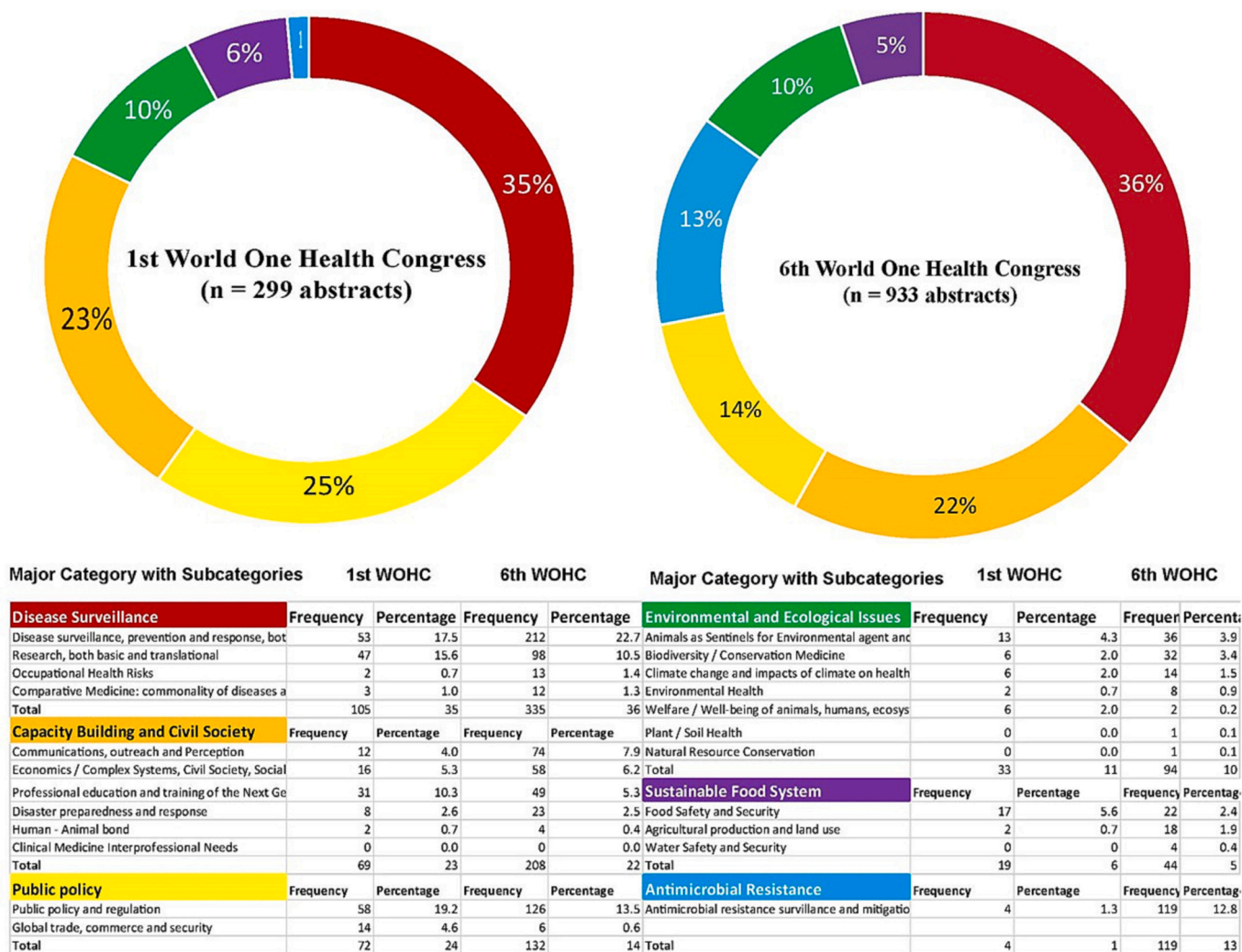


Fig. 2. Categories (ring) and subcategories (background table) of abstracts presented at the 1st and 6th WOHC. Percentage in central ring are the percentage of total abstracts of each category, while numbers and percentages in the background table are absolute frequency and percentage of submissions for each subcategory for both congresses.

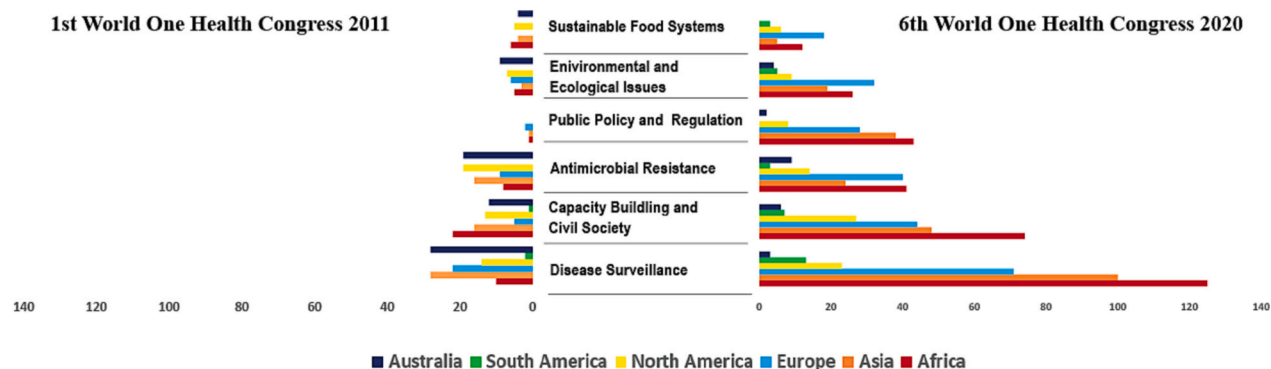


Fig. 3. Absolute frequencies of One Health abstracts based on regions and categories as shown by horizontal bar diagram.

major theme within the 1st WOHC, but the number of abstracts increased 13-fold during the 6th WOHC (Fig. 2).

At the country level, there appeared to be a relationship between research category and development in the 6th WOHC. Studies falling within the ‘disease surveillance’ subcategory dominated submissions from MHD index countries such as Pakistan (33/53 (62%)) and Nigeria (18/59 (31%)) and LHD index countries such as Tanzania (14/29

(48%)) and Ethiopia (11/34 (32%)) based on corresponding author affiliation (https://touseef.shinyapps.io/04_04/, Supplementary file 1). In contrast, submissions from VHHD countries, such as the United Kingdom and the United States, focused on the subcategories ‘basic and translational research’ (14/92 (15%)), and “public policy and regulation” (11/66 (17%)) respectively (based on research study site), during the congress (supplementary file 2). Most abstracts (481/932 (52%))

came from corresponding authors from VHHD index countries. The distribution of abstracts from other countries were: HHD index countries (101/932 (11%)), MHD index countries (165/932 (18%)) and LHD index countries (181/932 (19%)). In terms of all three criteria (study sites, corresponding authors affiliation, and international collaboration), there are still several geographical regions which were poorly represented at both Congresses, such as the Middle East, the Caribbean, or Eastern Europe.

There was a statistically significant relationship between corresponding authors and HDI of the country at 1st WOHC, but this was not apparent at the 6th WOHC. It can also be inferred by the looking at the correlation coefficient for international collaboration and HDI for these two conferences, which showed a decreasing trend with time, based on abstract data (Fig. 4).

4. Discussion

One Health is an interdisciplinary area of research that gained prominence amid global anxiety about pandemic preparedness [25,26]. One Health asserts the importance and interconnection of a range of issues such as emerging zoonoses, climate change, natural resource conservation and biodiversity loss, all of which are linked with the emergence of pandemics [27,28]. In this study, we sought to identify One Health regional and sectoral gaps based on abstracts presented during the 1st and the 6th World One Health congresses. We found that fewest abstracts addressed “Ecological and Environmental Issues” and “Sustainable Food Systems” across both Congresses. AMR related research increased by 13% from the 1st to the 6th WOHC.

Unsurprisingly, international collaboration appears to enhance the representation of MHD and LHD index countries at these Congresses.

There was an apparent regional bias in One Health research related to “Public Policy” with most contributions coming from authors from VHHD and HHD index countries (United States, United Kingdom) whereas research in MHD index countries (Pakistan, Nigeria) and LHD index countries (Tanzania, Ethiopia) focused mostly on “Disease Surveillance” during the 6th WOHC. It is not possible to conclusively infer the rationale, but it would be interesting to explore whether this is needs-based, reflecting national research priorities within MHD, and LHD index countries.

The WOHC is perhaps the world’s largest One Health platform, and the profile of the abstracts provides a useful snapshot of current One Health research landscape. However, any analysis will be constrained by biases associated with abstract submission, selection, presentation, and publication. Although the Congress offers considerable support, especially for early career researchers and post-graduate students, the registration (and travel and subsistence) fees and facility of travel (i.e. visas) may deter contributions from researchers, particularly those in MHD and LHD countries [18,29]. The location of the Congress is undoubtedly an important determinant in who attends the meeting [29]. Perhaps more important is to note which countries have no representation at the meeting; >100 countries are missing— most of which are in the Middle East and other conflict-affected regions. These countries, paradoxically face some of the world’s greatest One Health challenges [30].

There is limited representation of the “Environmental and Ecological themes” at both Congresses. This result generally supports the results of

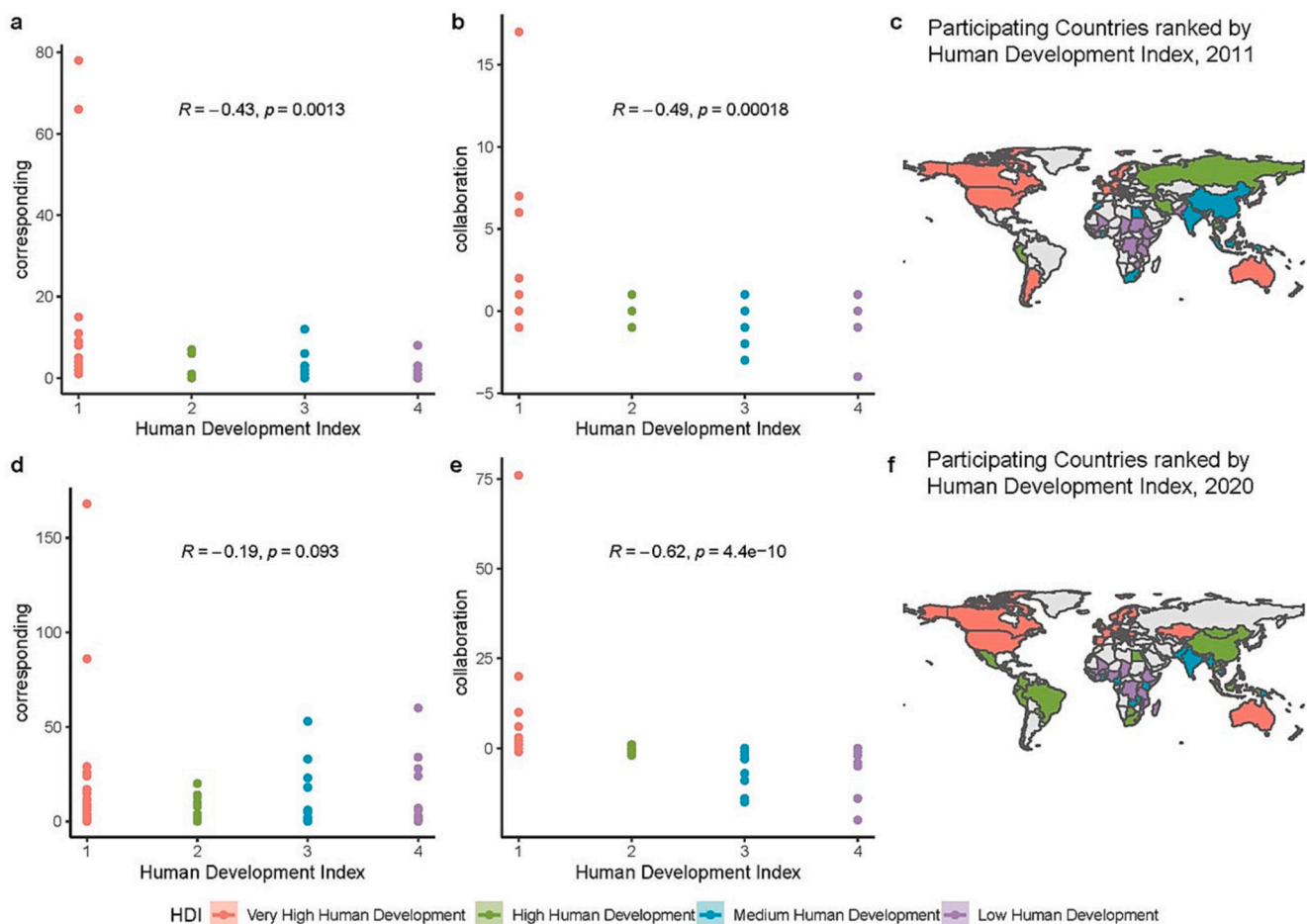


Fig. 4. Human Development Index Comparison of Participants Countries: 1st WOHC (a, b, and c) and 6th WOHC (d, e, and f) at corresponding authors and International One Health collaboration level.

previous studies [5,7,12]. The recent recommendation by One Health High Level Expert Panel (OHHLEP) stressed the importance of inclusion of environmental context and its sustainability in One Health research [2]. Ecosystem Health is core to any solution to the array of challenges including emerging zoonoses that humanity currently faces [31]. The OHHLEP expanded the One Health definition to capture broader interdisciplinary research areas, emphasizing the importance of maintaining ecosystem health to address future global One Health challenges [2]. Environmental dynamics not only have a role in propagation of disease spillover at individual and population levels but also exert an important influence on sustainable development. For instance, environmental extremes like extreme heat events due to climate change and land use can overwhelm the physiological tolerance of organisms and deteriorate landscape immunity, with serious implications for zoonotic disease emergence. Similarly, these changing environmental dynamics have a huge influence on the geographical distribution of important disease vectors, as well as influencing human behaviors [32,45]. The inclusion of climate change research in One Health was emphasized by both the Manhattan (2004) and Berlin Principles (2019) [5], and is linked with many other One Health issues such as species-extinction crisis [33], habitat and soil degradation [34], wildlife mass die offs [35], exploitation of wild species through proliferation of wildlife trades [36] and pollutions [37], which can severely jeopardize life on our planet [5]. Despite the recognition of increasing breadth of the OH landscape, there is still limited representation of these issues at both congresses. Perhaps this will change in future as researchers start to recognize environment as a cornerstone of positive health and well-being outcomes.

The “Sustainable Food Systems” category was consistently poorly represented at both congresses. A climate change crisis also affects food production because rising temperatures, sea levels, changes in rainfall patterns and water temperatures, ocean acidification, and more frequent and intense extreme weather events will affect how and where food is produced [38]. Ignoring this broad area of research means compromising world sustainable food production. ‘Food safety and security’, ‘water safety and security’, ‘agriculture production and land use’ are the integral part to ensure food required for future generations [39,40]. Intensive forms of livestock agriculture such as concentrated animal-feeding operations are required to meet projected demands for protein, but such practices may breach food safety protocols and can create environmental hazards that can speed up the evolution and spread of novel pathogens, including zoonotic viruses and AMR bacteria [40–42]. The increase in AMR-related research at the WOHC over the last decade likely reflects the increasing global concern and intensified political commitment to addressing this challenge (see for example the inclusion of AMR in the UN 2030 SDGS and the adoption of resolution at 71st General Assembly (UNGA) session in 2016).

We did not identify any topics addressing ‘clinical demands for interrelationship between health professions’, which is a subcategory under “Capacity Building and Civil Society”. Strengthening sectoral collaboration and knowledge sharing demands researchers to look beyond disciplinary and cultural silos [43]. Sectoral collaboration among One Health professionals has been impeded by separate regulatory functions and funding priorities [41,43,44].

5. Conclusions

The WOHC is arguably one of the largest and most inclusive Congresses on One Health research in the world. WOHC abstract publications thus offer an unrivalled opportunity to assess the One Health research landscape over time. This study offers a reflection on the evolution of global OH research, as well as insights into potential interdisciplinary and geographical biases, and international collaboration and partnerships. Identifying disciplinary gaps and emerging priority areas for future research is important to inform future One Health activities. There is currently limited representation of “Environmental and Ecological issues” and “Sustainable Food Systems” within the World One

Health Congress, and this appears not to have meaningfully changed over the last decade despite greater attention on global sustainable development challenges. Underrepresented OH themes can be strengthened through targeted international collaboration and capacity building, especially for resource-poor nations.

The evolution of One Health research (by contrasting the research landscapes between the first and sixth WOHCs (a decade later), reveals an improvement in global participation in One Health research. International collaborations have enabled some low and middle human development index countries to make significant contributions to One Health research. However, there is still a considerable gap between Very High Human Development Index countries and other countries with a lower human development index, when it comes to One Health research priorities and the number of studies conducted. Similarly, there is noticeable differences in operational versus strategic research priorities among the represented countries at both WOHC. There is need to widen outreach for global One Health participations to overcome the highlighted regional and sectoral gaps in One Health research. The results of the study also highlight potential regional differences in One Health research priorities, with respect to emphasis on operational (surveillance) versus strategic (policy) One Health activities. Finally, some geographic regions remain poorly represented by corresponding authors at the Congress and there remain potential asymmetries between the location of funding recipients and study subjects.

Author contributions

TA conceived the study, data entry, performed the statistical analysis and data visualization, and drafted the manuscript. MFT conceived the study, TK, LB contributed to study conception and writing the manuscript. All authors read and approved the final manuscript.

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Consent statement

Not applicable.

Ethical approval

This work was considered by the Institutional Review Board at Texas Tech University, and it was determined that Human ethics approval is not required.

Declaration of Competing Interest

The authors declare no conflict of interest.

Data availability

The datasets generated and analyzed during the current study are available in the Dryad repository at Ahmed, Touseef; Tahir, Muhammad Farooq; Boden, Lisa; Kingston, Tigga (2023), Future directions for One Health Research: Regional and Sectoral Gaps, Dryad, Dataset, <https://doi.org/10.5061/dryad.79cnp5htz>.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.onehlt.2023.100584>.

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