

Characterizing how One Health is defined and used within primary research: A scoping review

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Abstract

Background and Aim: One Health (OH) approach can be used in multiple ways to tackle a wide range of complex problems, making OH research applications and definitions difficult to summarize. To improve our ability to describe OH research applications, we aimed to characterize (1) the terms used in OH definitions within primary research articles reporting the use of the OH approach, and (2) the who, what, where, when, why, and how (5Ws and H) of the OH primary research articles.

Materials and Methods: A scoping review was conducted using nine databases and the search term “One Health” in June 2021. Articles were screened by two reviewers using pre-specified eligibility criteria. The search yielded 11,441 results and screening identified 252 eligible primary research articles. One Health definitions and 5Ws and H data were extracted from these studies.

Results: Definitions: One Health was labeled as an “approach” (n = 79) or “concept” (n = 30) that is “multi/cross/inter/trans-disciplinary” (n = 77), “collaborative” (n = 54), “interconnected” (n = 35), applied “locally/regionally/nationally/globally” (n = 84), and includes health pillars (“human” = 124, “animal” = 122, “environmental/ecosystem” = 118). WHEN: Article publication dates began in 2010 and approximately half were published since 2020 (130/252). WHERE: First authors most often had European (n = 101) and North American (n = 70) affiliations, but data collection location was more evenly distributed around the world. WHO: The most common disciplines represented in affiliations were human health/biology (n = 198), animal health/biology (n = 157), food/agriculture (n = 81), and environment/geography (n = 80). WHAT: Infectious disease was the only research topic addressed until 2014 and continued to be the most published overall (n = 171). Antimicrobial resistance was the second most researched area (n = 47) and the diversity of topics increased over time. HOW: Both quantitative and qualitative study designs were reported, with quantitative observational designs being the most common (n = 174). WHY: Objectives indicated that studies were conducted for the benefit of humans (n = 187), animals (n = 130), physical environment (n = 55), social environments (n = 33), and plants (n = 4).

Conclusion: This scoping review of primary OH research shows a diverse body of work, with human health being considered most frequently. We encourage continued knowledge synthesis work to monitor these patterns as global issues and the application of OH approaches evolve.

Keywords: global One Health research, knowledge synthesis, one health applications, one health definitions.

Introduction

Holistic approaches to health have developed over millennia under various concepts, dating back as far as Hippocrates (460 BCE–367 BCE) who highlighted human health’s interdependence on clean environments [1, 2] and indigenous communities around the world who have recognized and supported the interconnectedness of human life, non-human life, and the environment since time immemorial to the present day [3, 4]. Global leaders have continued to amplify holistic approaches, such as Dr. Rudolf Virchow

establishing the concept of zoonosis in the 1800s to recognize shared diseases in humans and animal, and Drs. James Steele and Calvin Schwabe founded the concepts of veterinary public health and veterinary epidemiology in the 1900s, respectively, to bring the value of veterinary knowledge to issues that spanned human and animal health [1, 2]. One Health (OH) emerged as a term to describe a holistic approach to health in 2004 at a Wildlife Conservation Society conference [1, 5] when several infectious diseases at the human, animal, and environment interface threatened public health in new, complex ways [6].

One Health has been used in research, higher education, and policy as a concept to describe complex issues since it was coined, and applying it as an approach has been offered as a novel way to holistically address these issues [7–16]. Its development over the 21st century has been well described in several publications [1, 2, 17–19] and it has risen to prominence

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through the efforts of various leaders and organizations, such as the One Health Initiative founded in 2006 to build a global OH community [2], the One Health Commission established in 2009 to promote OH collaborations and resources [20], and the more recent formation of the United Nations One Health Quadripartite (Food and Agriculture Organization, World Organization for Animal Health, World Health Organization (WHO), and United Nations Environment Programme) and their OH High Level Expert Panel (OHHLEP) advisory group [21, 22]. Despite the considerable efforts of OH champions, and OH being relevant to many global health issues, the public is often unaware of OH and those who actively use it can also struggle to describe what it is and how it is used [23–25].

A variety of resources have been created to support a better understanding of OH. One such resource is the new, expert-informed definition offered by OHHLEP [26]. Many alternative definitions exist, but a unifying theme among definitions is that OH acknowledges the interdependent health of animals, humans, and environments [27–29]. These three types of health will be referred to as the classic health pillars within this article.

More recently, the environmental health pillar has been further broken down into natural and built physical environments, as well as socially constructed environments, such as political and financial [26]. Plant health is also now recognized as a potential separate pillar [30]. Beyond health pillars in definitions, the concept of working together across different sectors, or multi/inter/trans-disciplinarity, has been highlighted as part of OH [27–29]. Other resources have also outlined competencies and reporting guidelines to support researchers interested in OH [31–35].

Recent reviews have attempted to improve our understanding of OH by identifying who is involved. A bibliometric analysis investigating disciplinary representation in OH literature found science authorship (e.g., microbiology and parasitology) to be the most represented and low collaboration across sectors (e.g., between human medicine, environment, and social sciences) [7]. A systematic review of disease transmission research, a proxy for OH research as determined by the publication's authors due to its relevance to the classic health pillars, found that ecologists and veterinarians were highly represented in this specific topic area [36]. However, questions remain regarding WHO is using OH, WHAT are its key components and relevant issues, WHERE is it being applied, WHEN did it start being used and how has it changed over time, WHY is it being used, and HOW are researchers applying it in their work. We will refer to these as the 5Ws and H of OH. Answering these questions will provide a broader, more complete understanding of OH research applications for both new and experienced OH practitioners alike.

The aim of this scoping review was to describe the 5Ws and H of primary research articles that reported using OH. To meet the objectives, we described the following characteristics of OH primary research articles: (1) Definitions of OH used, and (2) publication dates, authors, locations, research topics, study designs, objectives, and other potential mechanisms for applying OH.

Materials and Methods

Ethical approval

This study did not require ethical approval because there were no human or animal participants. This review was reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [37].

Study period and location

Conceptualization to submission of this review was conducted from 2019–2023, with the data collection and analysis occurring in 2021–2022. This review was conducted by a research team located in Guelph, Ontario, Canada.

Protocol registration

The protocol for this scoping review was published in 2020 and is available in the University of Guelph Atrium [38]. This section summarizes key methodological details and protocol deviations. The methods were informed by the scoping review framework described by Arksey and O'Malley [39].

Eligibility criteria

Journal articles, theses, and dissertations that described primary research studies in English, included the term 'One Health' in their title or abstract, and included a statement of using a OH approach within the full publication were eligible.

Indicating the use of OH can be written in various ways and phases (e.g., a concept, approach, framework, or way of thinking) and all variations were eligible if OH use was clearly stated. For example, stating that "a OH framework was applied to this research" and "the OH concept was used to inform the methods of the present work" would be considered a clear statement of OH use and these articles would be eligible for this criterion. The phrase "OH approach" will be used to broadly encompass all eligible variations for the remainder of this paper.

It was believed that research teams who devoted resources to the use of an OH approach would likely report the term in the title or abstract and not only in the body. The potential impact of this eligibility restriction was considered minimal, and a test analysis of this assumption is available in the protocol [38].

Review articles, other non-primary scholarly publications (e.g., commentaries), and gray literature (e.g., conference proceedings and policy documents) were excluded to focus on original, direct applications of OH within primary research settings. Other holistic

approach terms such as One Medicine, EcoHealth, and Planetary Health were not eligible.

Information sources

Searches were conducted in nine discipline-diverse databases: ABI/INFORM through ProQuest (1971 – current), Academic Search Premiere through EBSCOhost (1975 – current), AGRICOLA through ProQuest (1970 – current), CAB Direct through CABI (1973 – current), JSTOR, (1878 – current) MEDLINE through Ovid (1946 – current), ProQuest SOCIOLOGY (1952 – current), PsycINFO through APA PsycNet (1887 – current), and Science Citation Index through Web of Science (1900 – current).

Search strategy

All database searches were conducted on June 28, 2021, without date, language, or publication type limitations beyond those of the databases used. The term “One Health” OR “One-Health” was searched for within title/abstracts. This broad strategy was employed to capture any title or abstract references to OH [38].

Search results were uploaded to EndNoteX9 (Clarivate Analytics, Philadelphia, PA, USA) and de-duplicated. Remaining records were uploaded to DistillerSR (Evidence Partners Inc., Ottawa, ON, CA) and de-duplicated again.

Selection of sources of evidence

For terminology within this article, “records” corresponds to citations for all types of publications retrieved from searches, “articles” are full publications, and “studies” are discrete studies within an article (i.e., one article could contain more than 1 study).

Screening was conducted in DistillerSR at two levels: (1) Based on information included in the title and abstract and (2) based on information included in the full-text. Two reviewers (SDP, JG) independently screened each record with agreement at the form level for title and abstract screening (i.e., reviewer agreement was needed for the overall inclusion or exclusion decision of a record), and agreement at the answer level for full-text articles (i.e., answers must have been consistent for each full-text screening question across reviewers throughout). If agreement could not be reached, a third reviewer (EJP) resolved conflicts at both levels. Reasons for full-text exclusions were reported. Reviewers were trained by CBW and SDP by pretesting 100 records for the title and abstract level and 10 articles for the full-text level to ensure clarity of the form and consistency of interpretation.

The full-text screening form was updated after protocol submission to separate combined questions for more specific exclusions. Articles needed a “yes” response for all questions to be eligible for data characterization. Articles were considered unavailable at the full-text stage if they could not be accessed through the University of Guelph library resources or publicly. Full-text screening included the following five questions:

1. Is the full-text in English?
2. Is it available?
3. Is it a scholarly journal article or thesis/dissertation?
4. Is it describing a primary research study?
5. Does the author/paper clearly state that the OH approach has been used in the described research?

Data charting process

Two reviewers (SDP, JG) charted data independently and in duplicate using DistillerSR. Reviewers were trained by CBW and SDP by pretesting 5 articles to ensure the clarity of the form and consistency of interpretation.

A full list of extracted data items can be found in the protocol [38]. A summary of items included in this manuscript with deviations from the protocol is shown in Table-1 and results not included in the manuscript can be found in Supplementary Document-1 (<https://doi.org/10.5683/SP3/2MW6RL>). The rationale for the data item selection was to provide the most informative and relevant information for the 5Ws and H of OH primary research.

Synthesis of results

The PRISMA flow diagram [40] was used to chart the screening process. Descriptive analyzes were conducted in Excel (Microsoft 365, Version 2103) (Microsoft Corporation, Redmond, WA, USA). The results are summarized in figures, tables, and described through relevant themes.

For OH definitions, terms with the same or similar meanings were combined for reporting.

When characterizing research topics (WHAT), studies could contain more than one topic if the research was conducted for contributing knowledge to multiple areas.

For locations (WHERE), location of first authors was determined from author institution affiliations and the full-text was searched for the location of the study.

Disciplines (WHO) were based on author affiliations. Disciplines were selected a maximum of 1 time per article regardless of how many co-authors represented this discipline; therefore, the maximum number of each discipline across all included articles was the total number of articles. A single affiliation was eligible to represent more than one discipline when appropriate (e.g., The Veterinary Epidemiology Economics and Public Health Group would be considered relevant to animal health, human health, and business).

For objectives (WHY), more than one pillar (e.g., human health) or type of objective (e.g., disease-related) could have been selected per study. Multiple study purposes (e.g., what the work sought to do) and study designs (HOW) could also be selected per study.

Results and Discussion

Selection of sources of evidence

The PRISMA study flow diagram [40] is presented in Figure-1. A list of all articles included

Table-1: Data items collected and charted for the review of One Health primary research.

Theme	Original data items	Added or edited data items (i.e., protocol deviation)
WHEN WHAT	<ul style="list-style-type: none"> • Year of publication • Definitions 	<ul style="list-style-type: none"> • All terms listed in definitions characterized instead of pre-determined terms
WHERE	<ul style="list-style-type: none"> • Research topics • First author location • Study location 	
WHO WHY	<ul style="list-style-type: none"> • Author disciplines • Purpose 	<ul style="list-style-type: none"> • Focus of objectives <ul style="list-style-type: none"> • Pillars (plant pillar option added) • Health versus disease versus other • Frequency and type of evaluation studies • Level of pillar integration
HOW	<ul style="list-style-type: none"> • Study methods 	
Supplementary Document-1	<ul style="list-style-type: none"> • Referencing of pillar concepts • Collection and/or analysis of data relevant to pillar concepts • Comprehensiveness of describing One Health context • Presence of collaborators listed in article • Populations included • Self-reported use of multi/cross/inter/trans-disciplinarity • Self-reported level of human-influence (e.g., urban and rural) 	

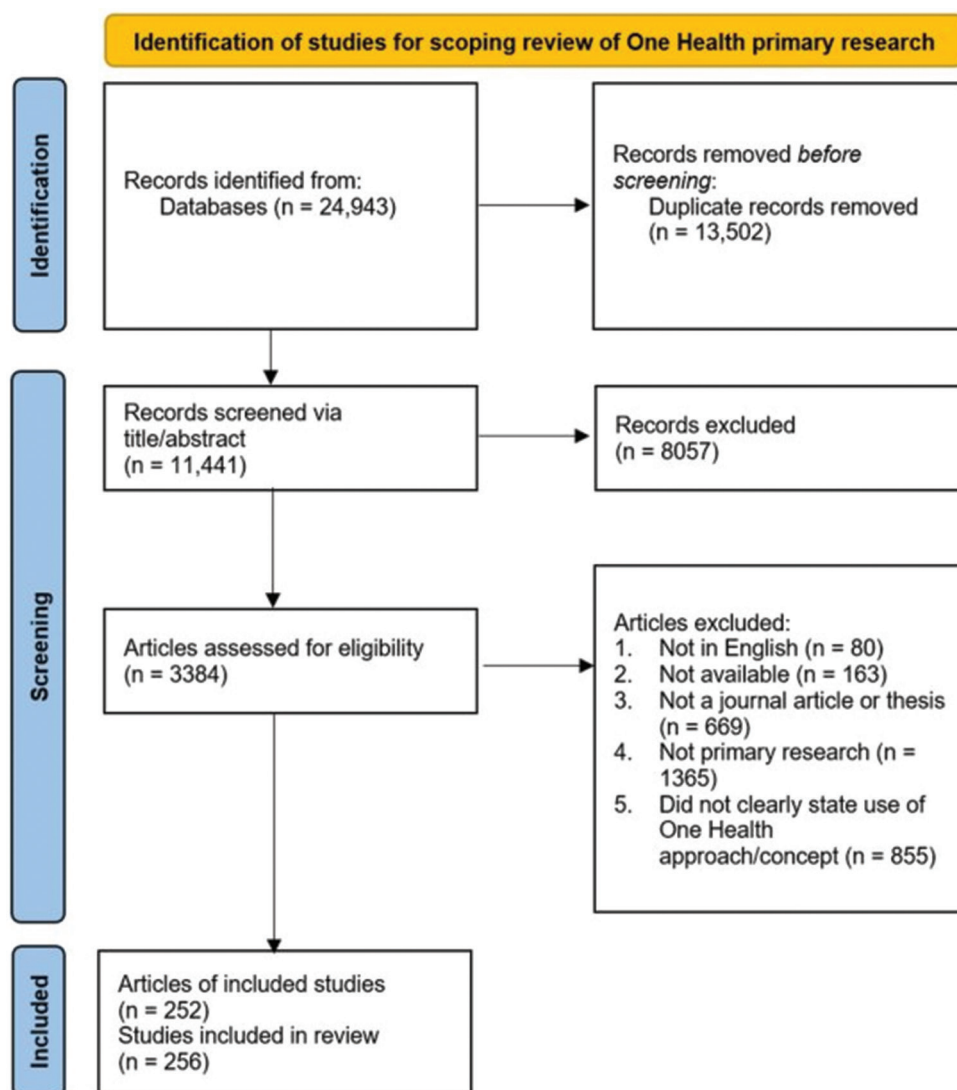


Figure-1: Preferred reporting items for systematic review and meta-analysis (PRISMA) study flow diagram [40] for a review characterizing One Health primary research.

in the review (n = 252) and full-text level exclusions (n = 3132) can be found in Supplementary Documents-2 and 3.

Articles were excluded at the full-text stage most frequently because they did not describe primary research (n = 1365), suggesting that the term

“One Health” is often used in non-primary academic works (e.g., reviews, commentaries, and conference proceedings).

Many articles that reached full-text screening passed all eligibility questions except for the final one that asked if they reported using the OH approach (n = 855). Some authors may have used the term OH to describe a problem, strengthen research justification, or made recommendations to apply the approach in the future. The use of OH in this way is appropriate, but the size of this excluded group compared to the eligible included articles (n = 252) potentially highlights that applying an OH approach is challenging in primary research practice. Potential barriers that might influence this implementation issue are lack of available, accessible, or known funding, governance and leadership, networks and collaboration opportunities, and training [41, 42].

Study characteristics and synthesis of evidence characteristics

The synthesis and study characteristics sections have been combined to outline the OH definitions that authors used in their primary research articles and the 5Ws and H of the body of evidence.

Definitions

Of the 252 articles, 121 (48%) provided one or more definitions of OH, often listed within the introduction or methods sections. The terms most frequently included within definitions are listed in Figure-2.

One Health was described as an approach (n = 79) and/or a concept (n = 30) in most definitions. The terms used to describe OH may indicate what it is perceived to be by OH users. For example, calling OH an approach may identify it as a method or action, whereas calling it a concept may identify it as a knowledge set or idea that can inform actions.

The characteristics of multi/cross/inter/trans-disciplinary/sectorial (n = 77), collaboration (n = 54), and interconnected/interdependent (n = 35) were

frequently attributed to OH. This shows an understanding that undertaking a OH approach requires contributions from multiple perspectives and sectors. The application of OH on various geographical scales (i.e., local, regional, national, global) was also frequently highlighted (n = 84) in definitions.

Most definitions reported in the articles referenced the classic health pillars (human, n = 124; animal, n = 122; environment/ecosystem, n = 118), but newer pillar concepts, such as plant health (n = 17), were not as frequently included.

Citations were provided for most definitions (n = 99). Citations were diverse and no single definition dominated the OH space. With the recent publication of the expert-informed OHHLEP definition [26], it may be of value to re-investigate this in the future to identify if the OHHLEP definition becomes the most prominent definition of OH and how that might impact OH research.

WHEN: Year of publication

The first English primary research articles that clearly stated using a OH approach, and included OH in their title or abstract, were published in 2010 (Figure-3). The number of articles published per year increased over time and over half of the included articles were published between January 2020 and June 2021. This shows a rapid adoption and application of OH within primary research in recent years. While the total number of peer-reviewed primary research articles (not only in OH) published yearly has also increased, the increase was 4% on average per year between 2008 and 2018 [43], which is lower than the average increase of 59% annually for the small body of OH primary research articles found between 2010 and 2018 in this review (n = 97).

With the term “One Health” being formally introduced in 2004 [1, 5], the 6-year delay in its appearance in the published literature may be due to several reasons. First, OH was initially introduced as a concept for describing interconnected aspects

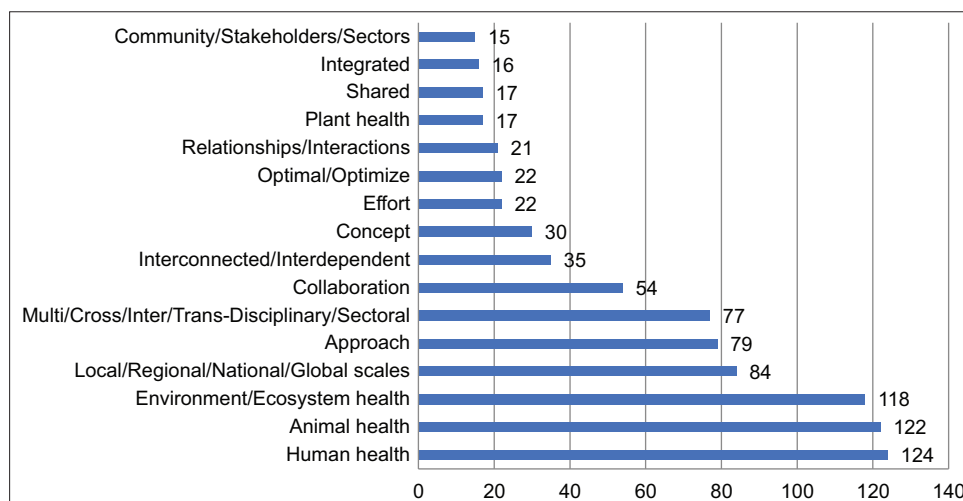


Figure-2: Most frequent terms (reported at least 15 times) included in One Health (OH) definitions within primary research articles that reported using the OH approach.

of health and not necessarily as an approach to use in research [5]. Then, to state that an approach was employed within primary research, researchers would need time to appropriately learn about it and use it. While OH education opportunities are rapidly becoming more available [8], few were available in the early to mid 2000s. The process of developing a project, conducting research, and preparing results for publication can also take several years, regardless of the method used. In addition, characteristics commonly referenced in OH definitions such as collaboration and transdisciplinarity (Figure-2) often require significant time to implement [44], which can further increase time to publication. Research groups may also have already been using similar, pre-established holistic approaches, such as the ecosystem approach to health and One Medicine [19, 45–47], but they would not be included in this review because the term OH was not used within that body of work.

WHAT: Research topics

Most studies focused on infectious and zoonotic diseases (n = 171) (Figure-4). Antimicrobial resistance and stewardship (AMR and AMS) studies were the next largest topic area (n = 47) (Figure-4) and represented a larger portion of studies published per year over time (data not shown). The growth of AMR and AMS research coincides with growing awareness of the impact of AMR on human health [48] and of

the drivers of AMR, such as prescription practices in human and veterinary medicine and environmental dissemination [49–52].

Some studies are not included in Figure-4 because they did not address specific topics or issues when applying OH (n = 22). This group primarily consisted of quantitative or narrative analyzes or reflections on OH implementation in educational programming and health systems.

Overall, the appearance of new research topics increased over time. While this is positive due to OH’s potential to tackle diverse issues, this growth may put OH at risk of becoming so broad that the term becomes less meaningful or more difficult to understand [6]. New applications of OH should be encouraged. Therefore, an accepted definition, such as the new OHHLEP definition [26], and the creation of flexible and comprehensive guidelines for how to use OH, will likely be helpful as the approach is applied to new topics.

WHERE: Continent representation

All continents except Antarctica were represented among first authors and data collection locations (Figure-5). Fifty-eight countries were represented by first authors and 99 countries were represented by study locations, indicating a wide geographic distribution of OH researchers and participants and showcasing the potential of OH to be applied to a variety of geographic contexts.

Oceania and South America had the lowest representation overall, and the majority of first authors had affiliations from Europe (n = 101) and North America (n = 70) (Figure-5). This distribution may be partially influenced by the total population of these geographical areas. Continents were more evenly distributed for study locations, with Africa (n = 62) and Asia (n = 61) most frequently reported (Figure-5). This signals a potential imbalance between where projects are being conducted and the location of those leading projects if first authorship reflects research management, which is likely project-dependent. Foreign research

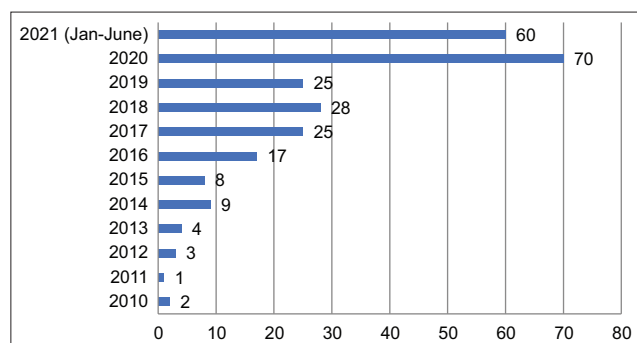


Figure-3: Year of publication of primary research articles that reported using the One Health approach (n = 252).

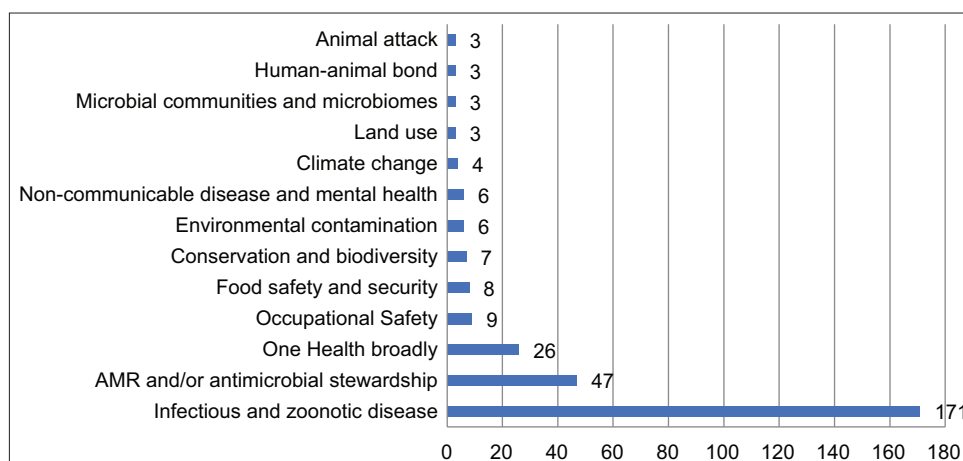


Figure-4: Most frequent research topics (reported at least 3 times) of primary research studies that reported using the One Health approach (n = 234).

leaders may not understand local contexts and, ideally, those who are central to the health issue(s) should be involved in leadership to ensure local perspectives are prioritized. This research leadership and location imbalance has occurred in other research areas [53]. Because many educational and government applications of OH have been established by African and Asian countries [8, 16], this imbalance may be limited to published English primary research articles and not reflective of OH use broadly.

Looking at first author locations over time, Europe and North America were the consistent

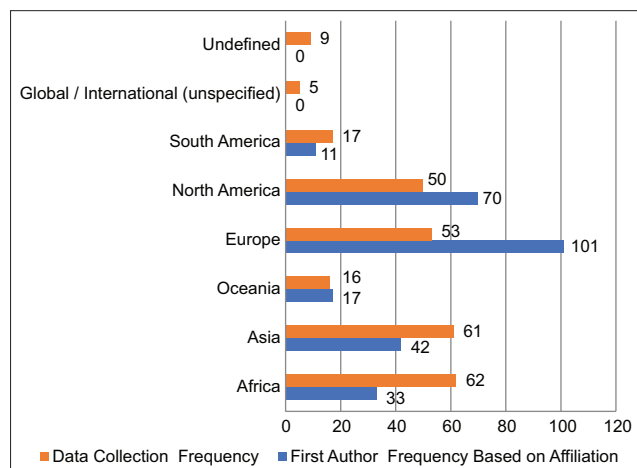


Figure-5: Continent representation in primary research articles that reported using the One Health approach (n = 252).

majority when analyzing 2014 onward (due to <5 studies being published per year prior). Combined, Africa and Asia grew to cover around 30% of studies in 2017 onward, indicating potential growth in this area that should be re-investigated in the future.

WHO: Author disciplines

Fields related to human (n = 198) and animal (n = 157) health were most represented (Figure-6). This may have been due to OH’s origins in zoonotic disease [6] and the high number of research articles in this topic area (Figure-4). While veterinarians have often been noted as leaders in OH [54, 55], the human health field was most represented overall. This finding could be due to several reasons such as: (1) a growing acceptance of OH within human-focused fields, (2) the approach’s application often being used for the betterment of humans (Figure-7), (3) the zoonotic origins of OH highlighting the need for doctors and veterinarians to work together [6], (4) a potentially greater number of human health researchers compared to animal health researchers, or (5) the potentially higher availability of primary research funding in human-focused disciplines compared to other disciplines [56].

Food/agriculture and environment-focused fields were the next most represented (Figure-6). This was not surprising as agriculture happens at the intersection of human, animal, plant, and physical and social environmental influences, it has been highlighted in the AMR crisis [48–50], and it contributes to food security. While environment has been included in

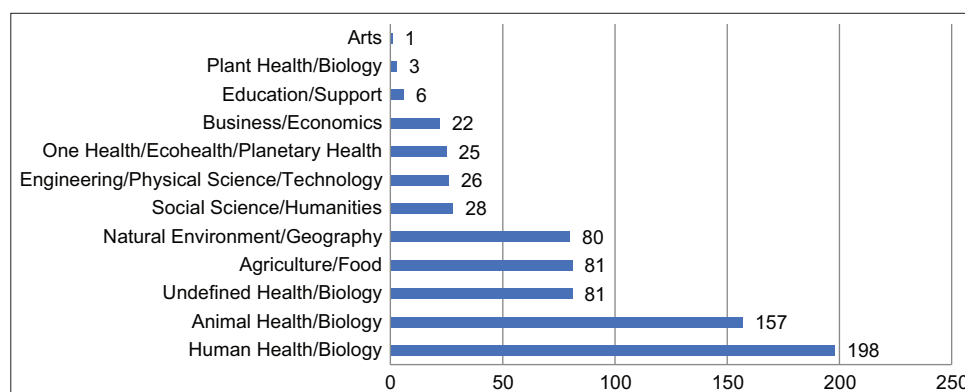


Figure-6: Author affiliation disciplines in articles that reported using the One Health approach (n = 252).

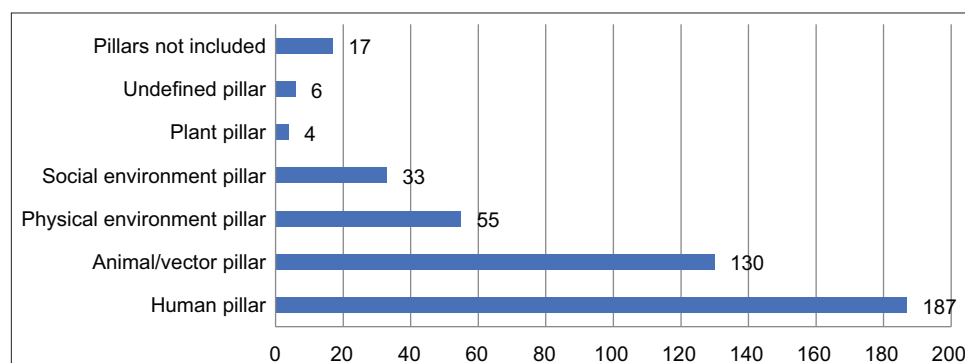


Figure-7: Pillars of focus in the objectives of primary research studies that reported using the One Health approach (n = 256).

OH descriptions with equal importance to animal and human health, it was less commonly mentioned in OH applications included in this review and in a previous evaluation [57]. The inclusion of environmental disciplines increased over time (data not shown), suggesting a growing appreciation of the importance of healthy environments in supporting human and animal health. It is also possible that inclusion of the environment is higher than reported here due to limited available information about authors. Departments representing the physical environment, with emphasis on the natural environment, were placed into the environment category but disciplines aligned with social environments (e.g., social sciences) and other disciplines that may represent the physical environment (e.g., engineering, agriculture) were not included as environment.

Social sciences/humanities (n = 28), engineering/physical sciences/technology (n = 26), holistic approaches (i.e., OH/EcoHealth/Planetary Health) (n = 25), and business/economics (n = 22) were also represented areas (Figure-6). Others have highlighted these fields as potentially beneficial to OH due to their ability to contribute non-traditional perspectives on health and provide a more comprehensive understanding of complex issues [58–60]. While their representation is low in OH to date, it is encouraging to see their participation in available studies.

Co-authorship across human, animal, and environmental health pillars was also investigated to understand how frequently this foundational aspect of OH was achieved. Only 35 articles (14%) included authors from human health, animal health, and natural environment/geography disciplines. Across all disciplines, 141 articles included representation from a combination of three or more of the disciplines listed in Figure-6 (n = 79 had three, n = 37 had four, n = 20 had five, n = 4 had six, n = 1 had seven). Multi-discipline co-authorship is a necessary but not sufficient aspect of multi/cross/inter/trans-disciplinarity and collaboration, frequent terms used within OH definitions (Figure-2). Reducing barriers to collaboration through dedicated infrastructure, such as collaborative networks, may continue to increase the occurrence of multi-discipline co-authorship. It is also likely that multi-discipline co-authorship may increase as the diversity of OH research topics grows.

Author affiliations may not accurately represent an individual’s field of study as there is a wide range of diversity and specialties within departments and institutions (e.g., veterinarians employed in medical institutions would be coded as human health). It would be beneficial for future research to conduct an in-depth analysis using authors’ education and work experience to accurately represent who is working in OH.

WHY: Study objectives

The reported objectives of each study were used to determine which pillar(s) the research was conducted

for (i.e., to benefit the pillar or improve our understanding of the pillar). Humans were the most frequent beneficiary of OH research (n = 187), with animals second (n = 130), and physical environments (i.e., natural and built) third (n = 55) (Figure-7). This aligns with the distribution of author disciplines (Figure-6), pillars included in definitions (Figure-2), and overall pillar inclusion (Supplementary Document-1).

While OH has strong roots in veterinary and animal science [6, 54, 55], more primary research funding may be available for work that centers human health. Some research conducted for the benefit of humans has also recognized that human health is improved through support for health of other pillars, resulting in their methods targeting non-human pillars despite being framed as studies to improve human health. Therefore, multiple pillars can benefit from OH research even when the human health pillar is centered.

The occurrence of multiple pillars of focus in study objectives was explored, and shared focus on the all 3 classic pillars was seen in 30 studies (Table-2). These studies may provide strong examples of classic OH research and have been bolded in Supplementary Document-2. Unsurprisingly, shared human and animal-focused objectives were most common, aligning with discipline representation (Figure-6) and research topics (Figure-4).

When looking at whether the objectives addressed a disease (infectious and non-infectious), health concept, or something other, most tackled disease (n = 204) (Figure-8). This may be due to disease outcomes, such as rabies incidence, having well-established literature to draw methodologies from compared to newer health outcome concepts,

Table-2: Most frequent pillar combinations of focus in the objectives of studies that reported using the One Health approach.

Pillar combinations	Number of studies (% of total studies, n = 256)
Human + Animal	92 (36)
Human + Physical Environment	43 (17)
Animal + Physical Environment	37 (14)
Human + Animal + Physical Environment	30 (12)
Human + Social Environment	26 (10)
Animal + Social Environment	14 (5)
Human + Animal + Social Environment	12 (5)

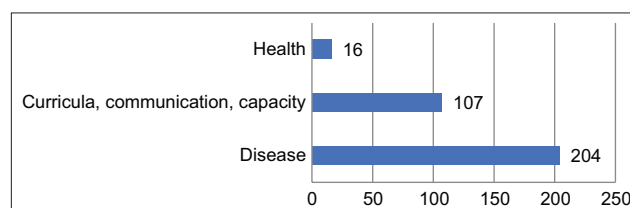


Figure-8: Types of objectives (i.e., what type of issue or concept the work addressed) in primary research studies that reported using the One Health approach (n = 256).

such as resilience, where measurement tools are still being validated [61–63]. It is also likely influenced by the high number zoonotic disease and antimicrobial resistance studies included in this review (Figure-4).

While reducing disease and disease burden is important for improving health, increasing the number of studies that strive to promote health, which goes beyond the absence of disease [64], may provide foundational examples of how to build and maintain healthy and resilient systems and communities rather than retrospectively responding to urgent disease threats after they occur. If OH can be used to successfully improve health when given sufficient tools and resources to tackle health concepts, this may provide evidence of the added value of OH.

Objectives that did not fall under either health or disease were categorized as curricula, communication, and capacity building objectives (n = 107) (Figure-8). The large number of studies focused on these topics reflects the ongoing challenge of defining what OH means, how to “do” OH, and what training and education are needed to further advance the use and application of this holistic approach.

WHY: Study purposes

Purposes that are associated with diseases (e.g., identifying risk factors), capacity and knowledge (e.g., resource building), and health concepts (e.g., understanding lived experience) were all reported (Table-3). The reported research purposes showed similar patterns to research topics, with increasing diversity of purposes over time.

HOW: Study designs

Quantitative and qualitative study designs were reported, with quantitative observational designs used most frequently (n = 174) (Table-4). Increasingly diverse methods (e.g., public health investigations, *in silico* models, and policy analysis) were used within each type of design over time, showcasing the flexibility of the OH approach. This was likely influenced by the increasing diversity of disciplines using OH introducing different methodologies and tools. Across all study designs, 32 studies included user, stakeholder, or expert consultation in their research, potentially supporting the collaboration and multi/cross/inter/trans-disciplinarity principles described in OH definitions (Figure-2).

HOW: Additional analyses

Additional analyses for HOW and other supplementary results are available in Supplementary Document-1.

Among studies that collected and/or analyzed data for more than one pillar, most studies integrated the results of their data by either descriptively or analytically drawing relationships and connections between pillars (n = 178) (Supplementary Document-1). These efforts were often used to describe how various actors and factors within a system interact with one another, helping to better understand the problem and potential

Table-3: Purposes for conducting studies that reported using the One Health approach.

Study purposes	Number of studies (% of total studies, n = 256)
Estimate prevalence/incidence	100 (39)
Assess interventions/methods/education	85 (33)
Understand lived experience/perception/knowledge	76 (30)
Identify risk factors and spatial mapping	51 (20)
Understand disease mechanism/presence/vector	47 (18)
Capacity/resource building	43 (17)
Skill development/education	32 (13)
Outbreak investigation/management	25 (10)
Prediction	11 (4)
Understand cost/benefit	11 (4)
Understand social relationships	10 (4)
Other (purposes <10)	19 (7)

Table-4: Types of designs used in studies that reported using the One Health approach.

Study designs	Number of studies (% of total studies, n = 256)
Quantitative observational (e.g., case-control)	174 (68)
Qualitative (e.g., thematic analysis of interviews)	53 (21)
Framework or methods development, application, and/or description (e.g., training program implementation narrative)	38 (15)
Experimental (e.g., randomized controlled trials)	36 (14)

consequences of interventions. The remaining studies most often attempted to integrate their results by considering some pillars as factors that impact the health of a different pillar (n = 44), such as analyzing dog ownership as a risk factor for human cases of Lyme Disease (Supplementary Document-1).

Evaluation studies have also been conducted within this body of OH literature (n = 67) (Supplementary Document-1). Forty-eight studies evaluated the efficacy of a OH approach and 17 evaluations took a OH approach (i.e., a project was evaluated through a OH lens) or evaluated the “OH-ness” of project (e.g., using the Network for Evaluation of OH framework [65]) (Supplementary Document-1). Evaluation studies are needed to help fill a critical evidence gap for OH and its effectiveness [66, 67].

Summary of evidence and overall themes

Infographic and point-form research summaries are available in Supplementary Document-4 as a learning resource.

Increasing use of OH

This review provides evidence that the number of OH primary research articles has grown substantially

in recent years. A bibliometric analysis conducted by a different research team in December 2019 identified 1067 articles that included “One Health” within their abstracts [7]. Based on the similar search strategies employed, that group of articles is similar to those that passed title and abstract screening in the current review, which totaled 3384 on the search date (June 2021), showing a substantial number of OH articles published since the end of 2019. Continuous synthesis methods, such as living scoping reviews (i.e., reviews that are periodically updated to add new, and relevant literature regularly), to monitor OH literature may be beneficial to maintain a reflexive understanding of this rapidly evolving body of work. The addition of social scientists in recent years highlight potential future changes that can be captured in these syntheses as social science-led OH articles have already contributed new philosophical, ethical, and conceptual ways of analyzing OH data, interpreting the results, and evaluating the OH approach [68, 69].

Since 2010, the OH approach has become more diverse in several areas within primary research. One Health has been used to combat and understand new issues, researchers from new disciplines have begun to use it, new methods have been introduced within its applications, and it has been applied in new places. This growth is expected to continue as more researchers and communities engage with the OH approach to tackle increasingly urgent and complex health and environmental threats. Earlier literature has highlighted the need to maintain meaning and clearly define OH as its applications become increasingly broad [6, 24]; therefore, grounding OH in unifying theories or definitions will be important. Wide acceptance of the new OHHLEP definition [26] and frequently cited characteristics identified in this review (e.g., collaboration and interconnectedness) can contribute to this. We also urge diverse communities to synthesize OH knowledge to continue this work.

Human-focus within OH

Another overall theme found in this review was an emphasis on humans. Despite OH’s veterinary origins [6, 54, 55], human health perspectives were most represented throughout the characterization of OH research (e.g., disciplines and pillars of focus). This could have been due to many reasons, such as power dynamics across disciplinary fields, available funding or researchers, and political or organizational agendas focusing on improving human health. While improving human life is important, ensuring that OH projects simultaneously co-benefit other areas (e.g., equitable social environments, animal health) is important to ensure long-term optimal health for all, including humans.

Even with a prominent focus on humans, broader representation and integration of study characteristics related to other pillars were still reported in the literature. Describing the complexity and breadth of a OH

issue is difficult, requiring a large amount of space within a manuscript and strong written communication skills. Human health may become the focus to help report outcomes or recommendations clearly and concisely. Reporting and communication resources, such as COHERE [35] and science communication education [70, 71], may help researchers more effectively describe the scope of their complex OH work in a way that others can easily understand and act on.

Limitations

The eligibility criteria required articles to include “One Health” or “One-Health” in their title or abstract. This likely reduced the number of eligible studies within the total population of OH primary research articles because some articles may have only included OH in the main text, causing them to be screened out at the title and abstract level. However, we believe that most researchers investing resources into taking a OH approach would likely recognize this effort by including the term in the title or abstract. Our quantitative approximation of how many articles were missed (available in the protocol [38]) also deemed the impact of missed articles to be minimal.

Only articles that reported using OH approaches were included in this review. Other holistic approaches, such as EcoHealth and Planetary Health, were not captured. Articles representing other holistic approaches may use different methods and have different focuses, and the inclusion of these other approaches would likely impact the identified themes reported here.

Only English articles were included. Although only a small portion of articles were excluded due to language of publications, our search strategy employed English terminology and would have missed non-English articles. This may have contributed to the high number of North American and European articles included compared to those from other continents. Future reviews would benefit from a more inclusive language search and eligibility criteria to ensure that any relevant non-English articles are included in the study.

Some data items extracted from the articles may not have been accurate. For example, disciplines were determined using reported author affiliations and authors may be employed in departments that do not appropriately describe their expertise. The same applies to first author location, which describes where they currently work but may not represent where they live or have lived in the past, both of which could influence perspective.

This review also required interpretation of reporting across very diverse articles and a different set of reviewers may have returned different results for more subjective data items. At the screening stage, a range of ways to state the “use of the OH approach” was seen across the articles, potentially impacting eligibility at the final full-text screening question. At the data characterization stage, all items required some

interpretation of what the authors reported except for year of publication and affiliation location. Some items were less subjective, such as data collection location, and others were more subjective, such as the pillars of focus reported in the objectives. Regardless, all data characterization required an in-depth reading of article contents and some form of interpretation. The difficulty of interpretation varied depending on clarity of reporting by authors, but poor methodological reporting within research publications has been commonly reported in many research fields [72, 73]. Both reviewers were affiliated with the same department (Department of Population Medicine, University of Guelph) and therefore came with a similar perspective that should be considered when reviewing the results presented here.

Conclusion

This scoping review identified the 5Ws and H of a rapidly growing body of primary research that reported using the OH approach (Supplementary Document-4). Overall, OH is being used more frequently and is being applied to a growing diversity of topics. Despite being championed by veterinarians historically [6, 54, 55], a focus on the human health pillar appears to dominate the OH primary research space.

We encourage future OH research and practice champions to continue producing OH knowledge syntheses. In doing so, we hope that our collective understanding of OH will continue to evolve and remain relevant in our current world as we work to address and solve urgent health and environmental crises.

Registration and protocol

The study protocol can be found at: <https://atrium.lib.uoguelph.ca/xmlui/handle/10214/21355>.

Data availability

Supplementary material can be found at: <https://doi.org/10.5683/SP3/2MW6RL>

Authors' Contributions

SDP: Developed the protocol, created the screening and characterization forms, trained reviewers, screened and characterized records, analyzed the data, and wrote the manuscript. EJP and DFK: Advised SDP and edited/provided expertise for protocol, data analysis, and manuscript. CBW and JMS: Edited/provided expertise for the protocol and manuscript. CBW: Trained reviewers. JG: Screened and characterized records and reviewed the manuscript. All authors have read, reviewed, and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

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