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RESEARCH

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Building the future One Health workforce in Eastern and Southern Africa: Gaps and opportunities

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Abstract

The Quadripartite comprised of the Food and Agriculture Organization (FAO), World Health Organization (WHO), World Organisation for Animal Health (WOAH), the United Nations Environment Program (UNEP), and the One Health High Level Expert Panel collectively support enhancing the One Health (OH) capacities of the workforce addressing OH issues; however, competencies for this workforce are not generally agreed upon, applied uniformly, or always relevant in the global South. The objectives of this study were to (1) develop an inventory of OH education offered by higher education institutes in Eastern and Southern Africa, and (2) define OH competencies relevant for OH training in Eastern and Southern Africa. A survey in 11 Eastern and Southern African countries was conducted with OH key informants purposively selected from higher education institutes offering OH education (n = 1–3/higher education institutes). Snowball sampling was used to identify additional higher education institutes/individuals. Results were validated by OH country representatives. Data were collected using questionnaires, and descriptive statistics were used to present the results. Forty-two questionnaires were completed from 29 higher education institutes, and 166 OH education interventions were reported with 69% being courses contributing to a degree, 21% as degree/diploma awarding, and the remainder were missing data (n = 16). Masters were the most common OH degree program of which the highest number of students taught were from public health/OH, food safety, and applied epidemiology. There are many OH educational courses and activities on offer in Eastern and Southern Africa; however, their total breadth is difficult to assess due to limited awareness of the availability of OH education not only between higher education institutes in a country but also even within a higher education institute between faculties. Numerous cross-cutting and technical competencies were considered essential to work in OH; however, this level of expertise is rarely logistically possible to provide in any single degree program. For OH education to be consistently applied, competency frameworks that are relevant to a region are necessary. Technical competencies are important from a disciplinary context; however, necessary cross-cutting competencies should be a focus in developing the future OH workforce.

One Health impact statement

A One Health multisectoral approach is needed to address global health threats at the interface of human-animal-environment. The quadripartite and One Health High Level Expert Panel (OHHLEP) identified One Health education as one of the action tracks that will contribute to achieving sustainable health and food systems and reducing global health threats. The OHHELP emphasized the need to identify existing One Health initiatives and evaluate the capacities related to research and implementation, especially those focusing on the One Health workforce. This study represents efforts to understand what One Health education is available in Eastern and Southern Africa (ESA), identify competencies relevant to One Health in ESA, and assess the need for resources to integrate One Health into curricula in ESA. The study findings highlight the need for standardized One Health competencies, low awareness about available

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One Health programs, both between and within higher education institutes, emphasizing the need for greater information sharing and collaboration. The findings provide the relevant stakeholders and practitioners in academia with the information and tools they need to support and promote the integration of streamlined One Health education at different levels. Awareness can be created on the identified One Health programs that are available at different levels for increased adoption.

Keywords: One Health, workforce development, Eastern and Southern Africa, education, competencies, capacity building, interdisciplinary collaboration, global health challenges

Introduction

One Health (OH) issues are interlinked in nature and are better addressed by approaches that are holistic, multisectoral, integrated, and transdisciplinary (Quadripartite, 2022). OH has been defined as an integrated and unifying approach that strives to achieve a sustainable balance and optimization of the health of individuals, animals, and ecosystems, acknowledging their interconnectedness (OHHLEP, 2021; Adisasmito *et al*., 2022). This multisectoral OH approach is necessary to effectively address global health threats particularly those at the interface of human-animal-environment, including, but not exclusively focusing on emerging and neglected diseases (OHHLEP, 2021).

The World Health Organization (WHO), World Organization for Animal Health (WOAH), Food and Agricultural Organization (FAO), and the United Nations Environmental Program (UNEP), as the quadripartite, and its scientific advisory group, the One Health High Level Expert Panel (OHHLEP), have drafted the One Health Joint Plan of Action (OH-JPA) and OHHLEP'S OH Theory of Change (ToC) respectively, to advocate and support implementation of OH. OH education has been identified as one of the action tracks that will contribute to achieving sustainable health and food systems, reducing global health threats and improving ecosystem management (Dar *et al*., 2022; Quadripartite, 2022). In addition, OHHLEP's annual report emphasizes the need to not only identify existing OH initiatives but also to evaluate the capacities related to research and implementation, especially those focused on the OH workforce. As such, OHHLEP has incorporated assessing the requirements for an OH workforce in their workplan to bridge this gap (OHHLEP, 2021).

OH education has the potential to create curricula that is appropriate for various levels of the OH workforce including primary, secondary schools, and higher education institutions (Dar *et al*., 2022). Gaps in harmonization of OH curricula as well as those in competency-based frameworks are key barriers for successful implementation of OH strategies (Amuguni *et al*., 2019; Dar *et al*., 2022). The OH-JPA has also highlighted the importance of enhancing OH capacities, to strengthen health systems, and build capacities necessary to establish a competent OH workforce. OH education can also contribute to enhancement of existing programs, resulting in competent OH enablers and facilitators, as well as structures and frameworks that can facilitate OH work in practice (Quadripartite, 2022). In the United States, Togami *et al*. (2018) identified plant health, antimicrobial resistance (AMR), and law to be less represented competencies in OH training; and epidemiology and environmental health/ecology as the highly represented ones. Mazet (2018) recommends three competency domains with 20 core competencies, which focus on health knowledge, global and local issues in humans, animals, plants, and the environment, and professional characteristics, with an emphasis on communication and interdisciplinary respect to enhance coordination and collaboration among OH professionals.

A major criticism of OH has been reliance on initiatives developed in the global North which would limit inclusion of regional or country-specific context and practices in the global South (Galaz *et al*., 2015). In order to promote global health perspectives, in locally applicable scenarios, it is important that views from individuals, communities, grassroots organizations, practitioners, and policy experts are considered (Galaz *et al*., 2015; Keune *et al*., 2017). Global North frameworks for OH education may not necessarily represent the needs of those in the global South. In cases where they may be applicable, they are not always being applied or used due to the lack of awareness of availability or their design remains based on formats and case studies that do not relate to the global South contexts (Galaz *et al*., 2015; Keune *et al*., 2017; Laing *et al*., 2023).

The Network for Evaluation of One Health (NEOH) proposes OH core competencies that are based on a global analysis of existing educational programs, and on the evolving needs of OH, to support capacity-building efforts within the OH workforce (Laing *et al*., 2023). These competencies complement the specific skills prioritized in current learning outcomes and respond to the call for cross-sectoral competencies outlined in the OH-JPA by the quadripartite. The aim is to enhance the workforce's capacity for effective action in the field of OH (Togami *et al*., 2023). To effectively achieve shared health goals across sectors and engage all relevant stakeholders, an updated set of core competencies is required to meet the needs of the growing human resources in the OH sector. Additionally, the core competencies and human resource needs should be in alignment with the local context and needs. Limited OH training in the global South creates gaps in essential skills for addressing global health challenges. To address this, OH programs should embrace transdisciplinary and multidisciplinary teaching strategies, involving professionals and students from diverse backgrounds (Soublis Smyth, 2017; Togami *et al*., 2018; Ossebi *et al*., 2022; Lapinski *et al*., 2023). This will equip future professionals and practitioners with the skills needed to address health issues across different areas and break down professional silos, promoting interdisciplinary understanding (Larsen, 2021).

In the framework of a development project with a specific objective aiming at training the future OH workforce, this study was undertaken to provide a better understanding of the status and needs in OH tertiary education in the region. The objectives were to (1) develop an inventory of OH education offered by universities in the Eastern and Southern Africa region, (2) describe OH competencies relevant for OH training in the region, and (3) assess resources needs for OH integration into curricula.

Methods

CONTEXT

The project, Capacitating One Health in Eastern and Southern Africa (COHESA) is a comprehensive four-year project aimed at raising awareness and promoting evidence-based policies related to OH in the Eastern and Southern Africa region. One of the project's primary objectives includes enhancing the capacity of educational and research institutions to train the next-generation workforce. This objective is implemented among other objectives such as fostering collaboration among government entities and stakeholders with OH mandates, identifying effective strategies to address OH issues, and building the capacity of both the public and private sectors to identify and implement OH solutions.

STUDY SETTING

The COHESA project is being implemented in 11 countries in Eastern and Southern Africa: Ethiopia, Kenya, Rwanda, Uganda, Tanzania (Eastern Africa), Botswana, Namibia, Malawi, Mozambique, Zambia, and Zimbabwe (Southern Africa) (Fig. 1). Within each country, a higher education institution is the partner organization which has an expertise in OH within the country.

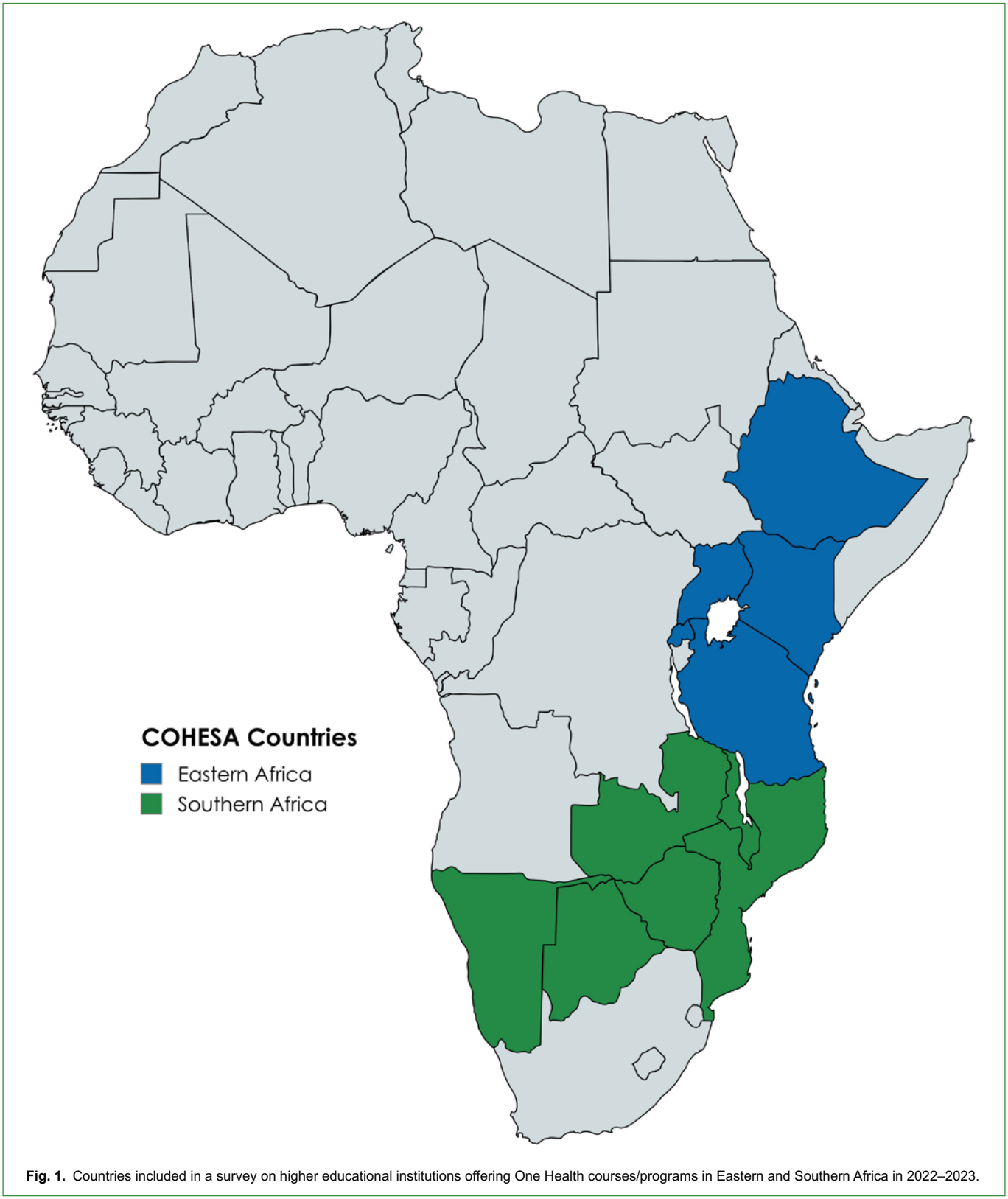

Fig. 1. Countries included in a survey on higher educational institutions offering One Health courses/programs in Eastern and Southern Africa in 2022–2023.

STUDY DESIGN

The study design used was a cross-sectional descriptive study with purposive sampling. COHESA project partners were requested to provide a list of higher education institutes delivering OH education in their countries, and for each institution, propose individuals (for interview/to be interviewed) as part of the study. The inclusion criteria for individuals to be interviewed included working in the target countries within the higher education institutes that offer OH education, and involvement in OH research or education. Snowball sampling technique was used to identify additional people and/or higher education institutes. We considered inclusion of 1–3 individuals per institution to account for varied responses from different faculties/departments.

DATA COLLECTION

A questionnaire was developed and included questions on: OH and/or OH-related courses offered by the higher education institutes, development of short and long courses (process, duration),

resources and institutional needs for OH training, enrollment for OH programs, employability of graduates, and OH training competencies informed by a prior desk literature review (Claxton, 2013; Fenwick, 2016; Frankson *et al*., 2016; Soublis Smyth, 2017; Mazet, 2018; Togami *et al*., 2018; Hoet, 2020; Larsen, 2021; Getachew *et al*., 2022; Nguyen, 2022; Rocheleau *et al*., 2022; Laing *et al*., 2023; WHO, 2020). For this study, programs and courses were considered as education interventions. Programs included training that resulted in a diploma or degree qualification. Courses are a subset of programs (it is noted that multiple courses are taught within programs). For this study, undergraduate programs are referred to as Bachelor of Science (BSc) programs.

Before the official administration of the questionnaire, a pre-test was conducted to finalize the tool. After the finalization of the questionnaire, the proposed participants were contacted through email and then a virtual meeting was organized. This recruitment, virtual meeting, and responses fell within the period between 24 October 2022 and 22 May 2023. During the virtual meeting, the aim and objectives of the study were explained, and participants were given opportunities to ask questions. Consequently, informed consent was sought. Although data collection was started at the time of this first meeting, it was not possible to complete, given the length of the tool because some questions required consultation with colleagues before responding. With this consideration, participants were granted a 1 to 2-week period to complete the questionnaire, and when necessary, consult with colleagues, especially where institutional details were required (not own perceptions). Reminders were shared via email. Responses related to higher education institutes offering OH and their programs/courses were validated by African One Health University Network (AFROHUN) country representatives in countries where AFROHUN was present. For other countries, country coordinators and partners from the COHESA project were consulted to validate the findings (inclusive of some of the authorship), ensuring that the data reached saturation in terms of responses.

STATISTICAL ANALYSIS

The raw data from the questionnaires were entered in Microsoft Excel® Spreadsheet. Analyses were primarily descriptive, including frequency tabulations and calculations of means with their corresponding standard deviations (SD).

ETHICAL CONSIDERATION

Ethical approval for conducting the study was obtained from the Institutional Research Ethics Committee (IREC) of the International Livestock Research Institute (ILRI) before commencement of the study, approval ILRI-IREC2022-20/3. Similarly, formal informed consent was obtained beforehand from each respondent.

Results

QUESTIONNAIRE RESPONSES

Forty-two completed questionnaires were returned (Table 1) resulting in an overall response rate of 82% of the 56 that had been introduced to the survey (Fig. 2). Out of the 42 participants in the survey, 11 were women and 31 were men (26 and 74%, respectively) (Fig. 2). Their professional roles were 13 lecturers, 6 senior lecturers, 6 professors and associate professors, 2 registrars, 5 deans and deputy deans, 10 directors, deputy directors and heads of departments. A total of 29 higher education institutes participated in the survey, 5 of which were private institutions (i.e., not part of the government system). In Mozambique, 11 people were contacted but no response was received by the time the interview period was closed.

ONE HEALTH EDUCATION DELIVERED BY HIGHER EDUCATION INSTITUTES

Sixteen (16/29) higher education institutes reported having delivered education that resulted in qualifications specific to OH, or included the term OH, or a term synonymous or very closely related to OH (13/29 did not). A total of 166 education interventions were reported; 150 were put into two categories; those that were related to certified academic programs (undergraduate, postgraduate) or delivered as courses contributing to the specific programs (16 records were missing some key details and could not be placed in any of the groups). The classification considered the program/course name, the duration, and if any certificate was awarded. Analyses found most interventions to be courses contributing to specific programs (76%; 115/150) (Box 1). Master's programs dominated the programs reported (54%; 19/35) (Fig. 3). Two continuous professional development (CPD) courses were reported. They each took about a week to complete. One post-graduate diploma course was reported.

Table 1. Number of key informant interviews completed per country in higher education institutes in Eastern and Southern Africa in 2022–2023.

	Number of people proposed for the interviews	Number of interviews conducted	Number of completed questionnaires	Number of institutions that had at least one questionnaire submitted
Botswana	12	8	6	3
Ethiopia	9	8	6	3
Uganda	6	3	2	2
Kenya	5	4	4	2
Tanzania	5	4	4	4
Rwanda	6	5	5	3
Malawi	11	5	4	3
Zambia	7	7	5	5
Zimbabwe	16	6	3	3
Namibia	11	5	3	1
Total	88	55	42	29

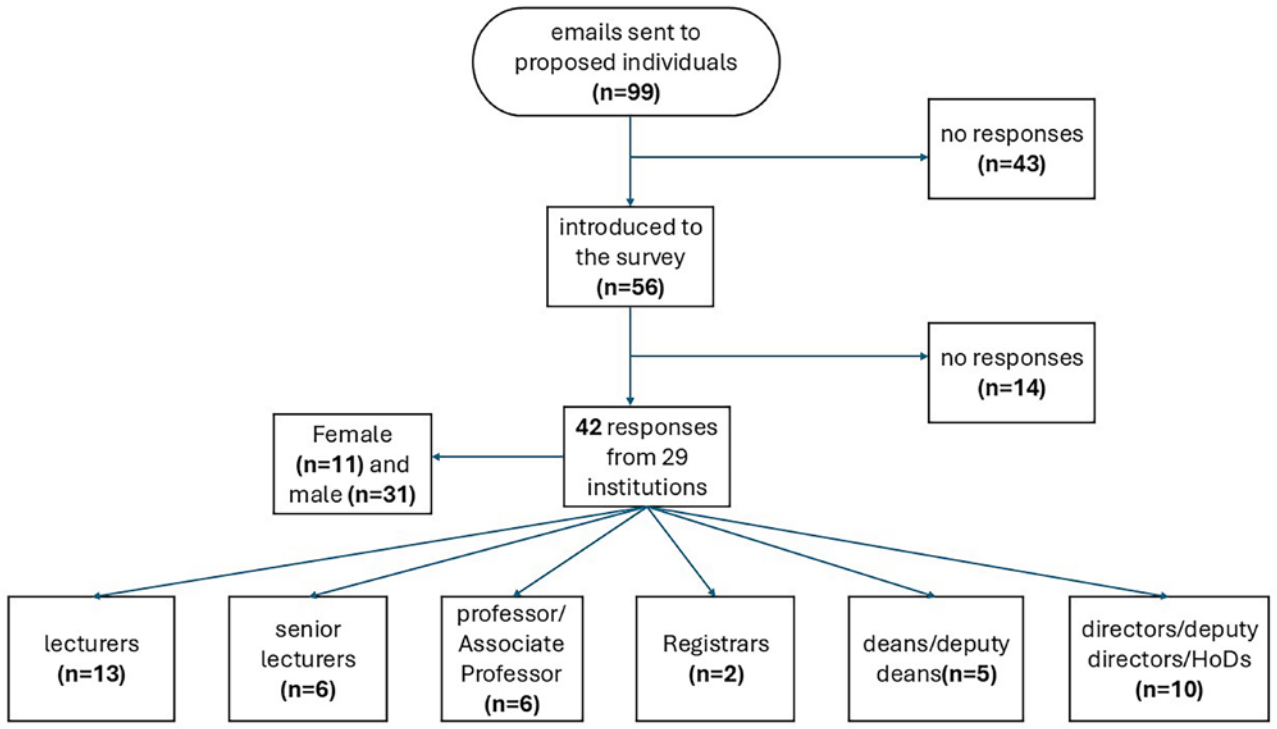

Fig. 2. Flow chart of respondents to a survey on higher educational institutions offering One Health courses/programs in Eastern and Southern Africa in 2022–2023.

Box 1. Sample of courses perceived to be offered as part of One Health or One Health-related degree programs as reported by key informant interviews from higher education institutes in Eastern and Southern Africa in 2022–2023.

Introduction to One Health; three triads of One Health; One Health field school; zoonoses and One Health; One Health; advanced One health and emerging zoonoses; zoonotic, emerging and re-emerging diseases; ecosystem health; ecology; environmental health; health economics; disaster prevention and preparedness; basic epidemiology; biostatistics; community based education; health systems management; conservation ecology; wildlife ecology and management; biodiversity; occupational safety and health in agriculture; wildlife ecology; wildlife animal welfare; wildland fire management; forest fire and other damaging factors; forest and range inventory and monitoring; natural resources policy and legislation

In addition to respondents providing data on their higher education institutes, participants were also asked to indicate if they were aware of other higher education institutes in their country involved in the delivery of OH courses. We have used these responses (n = 25) to enrich data received from questions asking about higher education institutes providing OH/OH-related courses within degree/diploma programs (Table S1, Supplementary Material). Through validation, there were an additional 14 responses, resulting in a total of 180 educational interventions (Table S1, Supplementary Material).

Based on the data, on average, it takes 4.8 (SD = 0.78, n = 10), 1.97 (SD = 0.11, n = 19) and 2.66 (SD = 0.57, n = 3) years to complete undergraduate, BSc, MSc, and PhD programs, respectively. The median number (range) of students taught per year was 116 (20–600), 12 (5–150), and 5 (1–35) for BSc, MSc, and PhD programs, respectively. Public Health and Applied Epidemiology were the MSc programs with the highest number of students (Fig. 4). Higher education institutes receive support from both local and external entities, with local support from national governments, partners and other higher education institutes. Centre for Disease Control (CDC), Africa Field Epidemiology Network (AFENET), WHO, Africa Centre of Excellence in Public Health and Herbal Medicine (ACEPHEM), Norwegian University of Health Sciences, University of Florida, Minnesota University, Tufts University, FAO, and AFROHUN are among the external organizations providing support.

EDUCATIONAL INTERVENTIONS AT HIGHER EDUCATION INSTITUTES THAT COULD POTENTIALLY BENEFIT FROM INTEGRATION OF ONE HEALTH

Education interventions that were perceived to potentially benefit from OH were reported by key informant interviews and organized by themes (Tables 2 and 3). The majority were undergraduate programs (63%; n = 188), followed by MSc programs (29%; n = 54), and PhDs (5%; n = 9), and one postgraduate diploma in infectious diseases was reported (3% non-degree awarding programs). Additionally, four diploma and two certificate courses (OH and infectious disease management) were identified. The average duration of these courses were 2.4 (SD = 0.8), 4.2 (SD = 0.8), 2.0 (SD = 0.1), and 3.4 (SD = 0.5) years for diploma, undergraduate, masters, and PhD courses, respectively. The median number of students taking the courses per year was 20 (7–60), 50 (10–800), 15 (5–50), and 5 (3–5) for diploma, undergraduate, masters, and PhD programs, respectively.

ONE HEALTH TRAINING COMPETENCIES AND RESOURCES

Epidemiology, OH principles, infection, and AMR were among the competencies considered essential for the OH workforce (Fig. 5). Behavioral economics, political economics, psychology, and law were reported as optional. Several cross-cutting competencies were identified (Fig. 6). Exchange visits, bursaries, and financial support were identified as the main resources that would benefit from the integration of new competencies in OH (Fig. S1, Supplementary Material).

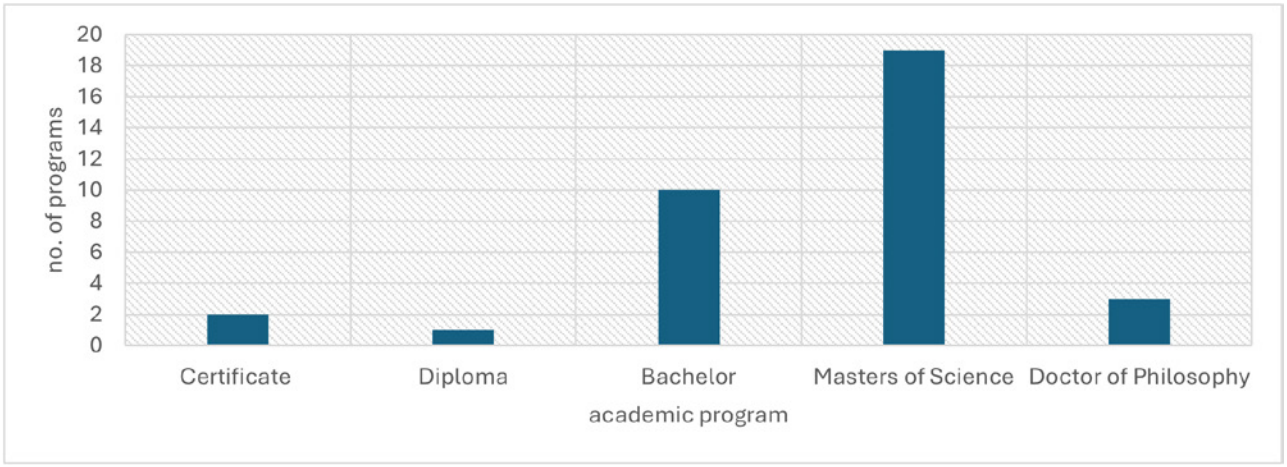

Fig. 3. One Health/One Health-related programs offered as reported by key informant interviews from selected higher education institutes in Eastern and Southern Africa, 2022–2023.

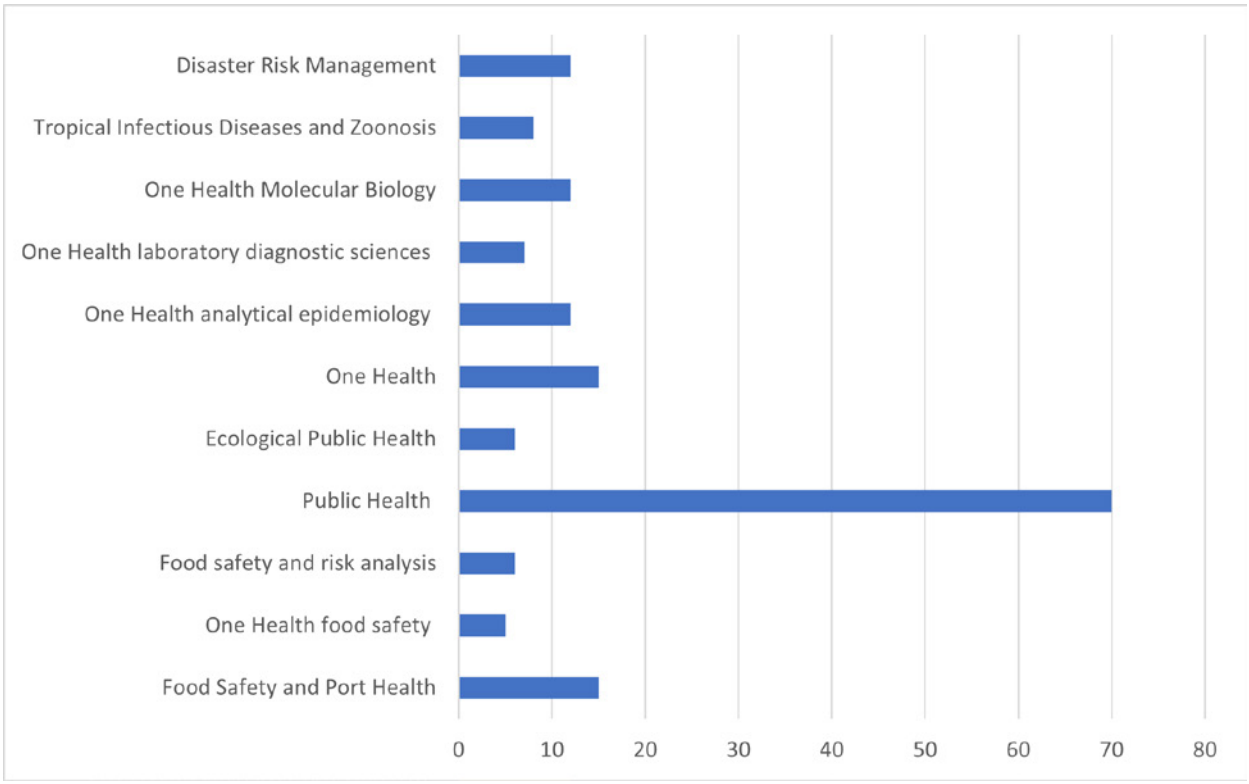

Fig. 4. Number (count) of students taught per year (X axis), for selected One Health (or One Health-related) MSc programs, as reported by key informant interviews from higher education institutes in Eastern and Southern Africa in 2022–2023.

CONSIDERATIONS FOR NEW ONE HEALTH PROGRAMS AND COURSES

For new trainings focused on OH, we asked participants to indicate the number of students that they considered critical to develop a new training, and the percentage that would be self-funded. The median number of students needed ranged from 19–40 dependent on the type of OH education intervention and required 20–30% of students to be self-funded (Table S2, Supplementary Material). Respondents indicated it takes 6.35 (SD=5.25) months to develop a 10–100-hour short course (from initiating it to admitting the first cohort of students). Whereas the process for developing educational interventions – diploma, undergraduate, and postgraduate- were reported to take about 18.85 (SD=11.51) months to develop. Higher education institutes reported the need for support to develop OH courses, which included laboratory support, training of staff, curriculum development, and setting of benchmarks (Fig. S2, Supplementary Material).

EMPLOYABILITY OF ONE HEALTH GRADUATES

We asked participants to state how easily they thought it was for OH graduates to be employed – in the countries, regions, and internationally – i.e., if they perceived it has improved, remained the same, or if it was harder after their OH specific training. Private and public sectors, academia, non-governmental organization (NGOs), and entrepreneurship programs were employment options considered. Irrespective of the sector, the percentage of participants that considered employability to be improved after OH specific education at higher education institutes was 64% for the

Table 2. Undergraduate courses that could benefit from One Health education as reported by key informant interviews from higher education institutes in Eastern and Southern Africa in 2022–2023.

Field	List of courses
Human, community health	• Clinical medicine and community health; community health; medicine and surgery; dental surgery; nursing; pharmacy; public health; demography and reproductive health. • Anthropology; sociology; human science and community service; development studies
Agriculture – crops, animal health	• Animal health; animal science; veterinary medicine; animal production and technology. • Agriculture; food security; conservation agriculture; crop science; agricultural economics; development economics; rural development and agricultural economics • Food science and technology; food nutrition and dietetics; bioprocess and post-harvest engineering; food processing technology • Biomedical sciences; biotechnology and laboratory science; medical laboratory; soil and water conservation engineering; range science; soil science and land resource management; vocational studies in agriculture with education. • Aquaculture; freshwater and fishery science; wildlife management; forest resources and wildlife management;
Environment/ecosystems	• Dryland economics and agro-ecosystem management; management of agro-ecosystems and environment • Environmental health; environmental science; soil and water conservation engineering; environmental science; environmental health sciences • Forestry and nature conservation; forestry and rangeland management; environment sciences and management; geo-informatics and environmental conservation; engineering in environmental engineering and management; wildlife ecology; geography; water and environmental engineering;
Cross-cutting/others	• Transport management; building and construction technology; surveying and geomatics; media studies;

Table 3. Postgraduate programs that could benefit from One Health education as reported by key informant interviews from higher education institutes in Eastern and Southern Africa in 2022–2023.

Field	List of courses
Human, community health	• Biostatistics and epidemiology; epidemiology; field epidemiology and laboratory management; field epidemiology; veterinary preventive medicine (field epidemiology); public health; public health pest management; field epidemiology; public health epidemiology; veterinary public health; veterinary epidemiology; health service management; health and biomedical sciences; microbiology; applied microbiology; One Health; international infectious diseases management; nursing (education, leadership and management);
Agriculture – crops, animal health	• Crop sciences; food science and technology; food technology; veterinary medicine; animal production; crop science; One Health; crop science; animal breeding; medical microbiology; tropical and infectious diseases; biological sciences; agricultural education and extension; animal production; soil science; crop science; human nutrition.
Environment/ecosystem	• Aquatic animal health and ecosystem management; tropical ecology; environment and climate change science; ecotourism and biodiversity conservation; environmental and occupational health; soil management and agro-forestry; soil and water engineering; water resources and environmental management; conservation and natural resource management; biodiversity conservation; environmental science and technology
Cross-cutting/other	• Management; gender and development; business administration in health systems

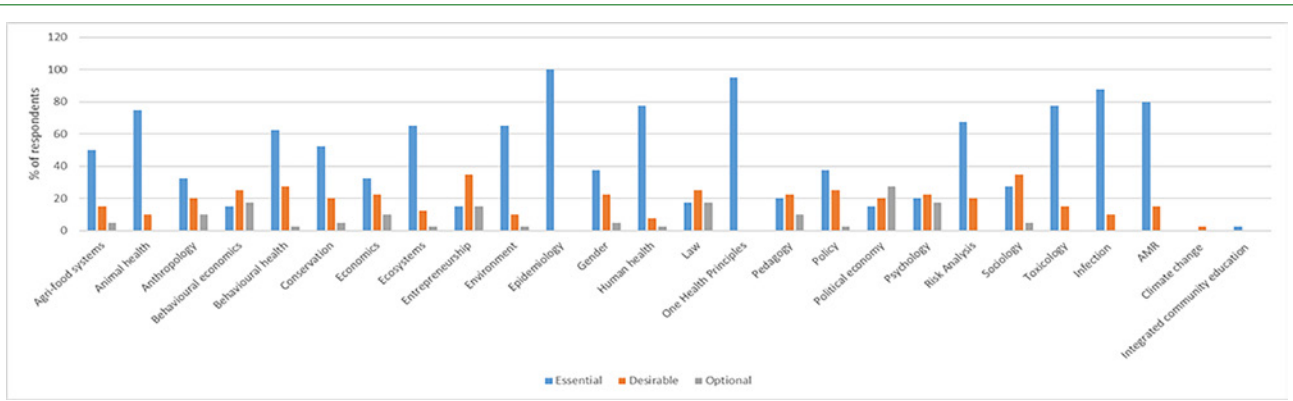

Fig. 5. Core technical One Health competencies as reported by key informant interviews from higher education institutes in Eastern and Southern Africa in 2022–2023.

national, 63% for regional, and 67% for international employment opportunities (Fig. S3, Supplementary Material).

NON HIGHER EDUCATION ONE HEALTH EDUCATION

We asked participants to indicate if their higher education institutes had conducted any form of OH education in the previous 5 years that targeted people not enrolled at the higher education institutes. Responses were categorized as AMR, zoonotic diseases, OH, tree planting, and environment. AMR training included stewardship, the use of antimicrobials in food animals and its role in dissemination of AMR to humans. Zoonotic disease training reports included preparedness, border inspection, COVID-19, and awareness on rabies. Environment-related topics included ecosystem health, proper use of pesticides, tree planting, waste management, community-led total sanitation, latrine construction, and compost production using food waste. Cross-cutting topics including communication, medical ethics, leadership, and risk analysis were also reported. These non-higher education trainings were delivered through a variety of approaches including face-to-face meetings (55%; 68/124), practical demonstrations including field visits (32%; 40/124), virtual (7%; 9/124), and other delivery approaches (6%; 7/124). Programs targeting school children were reported in five universities and included rabies, introduction to OH, tree planting and awareness on AMR. OH content was available as handouts and videos, delivered as modules or through outreach (Table S3, Supplementary Material).

Cross-department activities, student clubs, and seminars were rated high in terms of their effectiveness in growing the future OH workforce via means of engagement of the workforce to include OH in their education choices and future careers (Fig. 7).

Discussion

Based on responses from 42 individuals from 29 higher education institutes in Eastern and Southern Africa, there is a clear presence of OH education being offered at all levels within the institutions, both for students and with outreach to community members (Fig. 7; Table S1, Supplementary Material). While OH education is present, one concerning finding was the lack of awareness within countries about what OH education is available. Not only was there a lack of awareness of what was available at other institutions but respondents also had limited awareness about what was on offer at other faculties in their own institute. This issue was evident when comparing results submitted by the respondents but was especially evident when results were validated with AFROHUN,

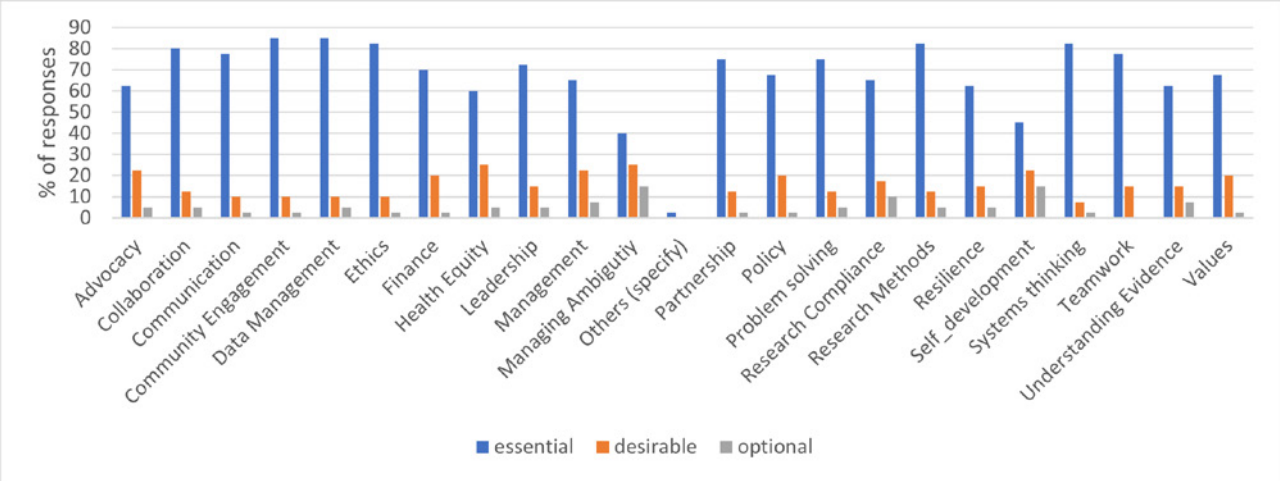

Fig. 6. Cross-cutting One Health competencies respondents were not limited to number of desirable competencies as reported by key informant interviews from higher education institutes in Eastern and Southern Africa in 2022–2023.

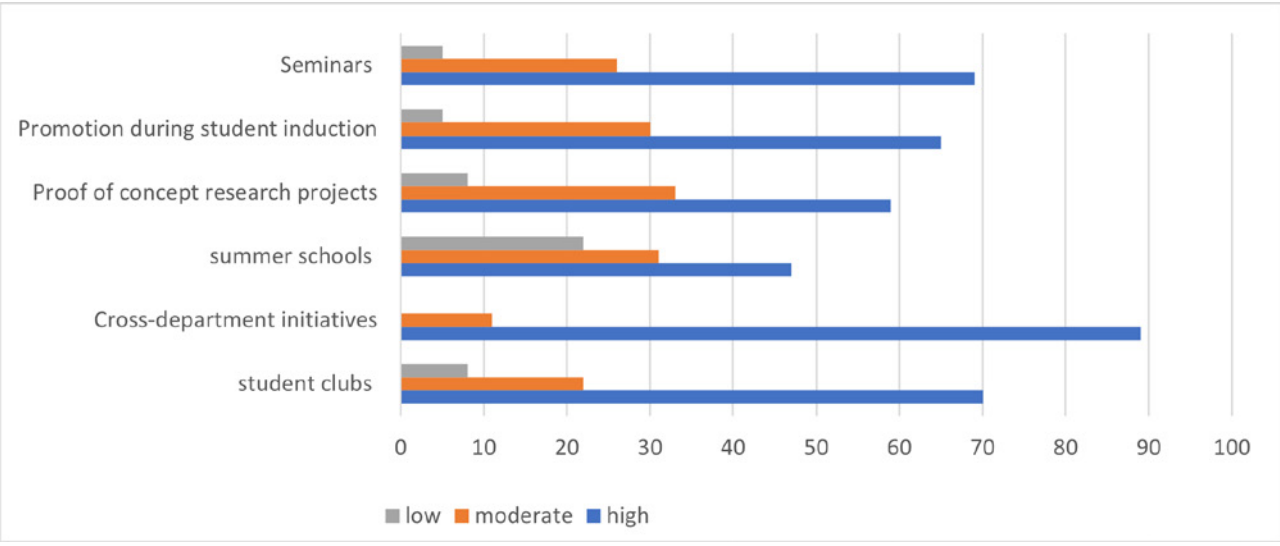

Fig. 7. Opportunities for growing future One Health workforce as reported by key informant interviews from higher education institutes in Eastern and Southern Africa in 2022–2023.

or COHESA country partners. For example, in Ethiopia, the entire list of education at higher education institutes on offer (Table S1, Supplementary Material) was revised after validation. In Kenya, the validation team had multiple disagreements with the list of education interventions from respondents. Given the overall response rate of 46% the list of OH education from these institutions cannot be considered comprehensive. Given the lack of agreement from those responding, it is clear there is limited awareness of OH education being offered within countries and even within institutions. This is not dissimilar from what was observed in the European Union where a centralized system to track OH education was suggested as a need (Keune *et al*., 2017).

Reasons for limited awareness of OH education available include the diverse definition of OH and what respondents consider OH, which is also reported in international OH settings (Fletcher *et al*., 2009; Zinsstag, 2012; Kesselring, 2021; OHHLEP, 2021). OH was defined within the questionnaire (Annex S1, Supplementary Material); however, this does not preclude respondents considering their own technical background when providing information on available OH education (Table S1, Supplementary Material), as well as opinions on when OH education was needed (Tables 2 and 3), and the competencies to work within OH (Figs. 5 and 6). This is a symptom of the siloed nature of sectors within OH, where individuals are aware of how OH applies within their field; however, they have limited interaction with those outside of their field to work in a multi or transdisciplinary manner needed in OH (Allen-Scott *et al*., 2015; Galaz *et al*., 2015; Soublis Smyth, 2017; Islam *et al*., 2020; Chiesa *et al*., 2021; Ossebi *et al*., 2022).

Respondents' opinions on OH competencies come from their technical area of expertise, and therefore many OH technical competencies were considered essential (Fig. 5). However, given that OH has been suggested to be offered across all levels of higher education institutes, for in-service professionals, and for primary and secondary students (Tables 2 and 3; Fig. 7; Tables S1 and S3, Supplementary Material), it would be very difficult to acquire all technical competencies. The inability to acquire all technical competencies is emphasized by the majority of OH education being offered through courses within programs. These courses are short in duration, and it would be especially difficult for all competencies to be taught in this manner. Within OH postgraduate programs, master's programs were the most offered, and within the estimated 2 years it takes to complete these programs; it would still not be logistically possible to teach every technical competency suggested as essential by questionnaire respondents.

The issue of numerous technical competencies being considered essential was also seen in a study from Rwanda, a recent review on competencies (Togami *et al*., 2018; Amuguni *et al*., 2019), and within a recent technical working group (TWG) contracted by the IUCEA to benchmark an OH Master's program (Mawa, 2022). The TWG represented the East African Community (EAC), a subset of the Southern African COHESA countries, and Ethiopia as OH experts from higher education institutes. Initially, this group also identified all technical competencies as essential as part of an OH Master's curriculum benchmarking process. With further discussion, the TWG recognized it was not possible to fit all technical competencies into a 2-year master's program. The TWG then decided the best approach was to consider all incoming master's students as having strong technical expertise from their undergraduate program, and that an OH Masters should mainly focus on cross-cutting competencies as the core. The technical competencies would be determined by the degree offering institution given the broad spectrum of students (and future workforce) enrolling in OH education. A similar process is ongoing within Southern Africa as part of the COHESA project, and the process there is similarly considered the cross-cutting competencies as the core requirements for an OH Masters. Given multiple sectors can and need to work in the OH field (Ossebi *et al*., 2022; Togami *et al*., 2023). It will be important to consider how to determine which OH competencies are suitable for all students, and which are more appropriate to consider within technical fields.

Our competency study results share a common thread with other studies that highlight the necessity for multidisciplinary cross-sectoral training approaches spanning the human, animal, and environmental domains (Soublis Smyth, 2017; Togami *et al*., 2018; Ossebi *et al*., 2022; Lapinski *et al*., 2023). Our work and these studies recognize the imperative to identify a set of competencies tailored for OH professionals, encompassing knowledge, skills, and behaviors. The convergence of these findings underscores a collective acknowledgment within the scientific community regarding the importance of cultivating a well-rounded skill set among professionals engaged in OH. The impetus driving the development of OH competency domains aligns with our study, emphasizing the need to equip professionals with a comprehensive set of skills that complement their specific areas of expertise (Calhoun *et al*., 2008; Frankson *et al*., 2016; Amuguni *et al*., 2019).

The difficulty in ascertaining which competencies are core for various OH education interventions is reflected in respondents indicating that OH education is needed in a wide variety of programs, courses, within CPD and the community (Tables 2 and 3; Fig. 7; Tables S1 and S3, Supplementary Material). While it is positive that many avenues of OH education are being considered, there is currently no systematic way to apply OH education or the competencies needed within each field and for each target audience. Benchmarking OH programs is one way this can be mitigated, and the upcoming Inter-University Council of East Africa (IUCEA) OH Masters benchmarks will assist with transferability of skills for graduates in the EAC (EACATS, 2018; Hon and Clarke, 2020; IUCEA, 2024). Hopefully, similar benchmarks can be developed for the Southern African region, as well as other programs and courses. This will help to ensure the transferability of skills within countries and fields of work, as well as regionally. While integrating knowledge across sectors, disciplines, and stakeholders is crucial, sustaining this integration capacity beyond the initial planning and implementation stages is a challenge. Efforts should be made to ensure continuous collaboration and knowledge sharing throughout the entire process (Ossebi *et al*., 2022).

Recently, well-recognized competency frameworks have been developed to guide OH workforce training and public health education. These include the OH framework outlined in Kassa *et al*. (2022), which includes as a resource library and competency framework across 15 domains, along with an evaluation toolkit compiled from OH workforce training programs worldwide (Kassa *et al*., 2022). The second available framework is European and from the World Health Organization, The Association of Schools of Public Health in the European Region (WHO-ASPHER) Competency Framework. WHO-ASPHER provides guidance on identifying and improving public health competencies, and it serves as a basis for developing context-specific competencies aligned with the European health policy framework (WHO, 2020). The OH-framework described in Kassa *et al*. (2022), and WHO-ASPHER framework can be used in designing curricula for degree and continuing professional development programs, assessing existing capacity and capability, and identifying training requirements. For example, partners of the OH Workforce Academy (AFROHUN/SEAOHUN) use the OH framework to establish core competencies for designing accreditable curricula and credentials for pre-service and in-service trainees, regardless of their discipline of origin since competency-based training of the OH workforce is essential (Kassa *et al*., 2022).

The benefit of consistently applying OH education could help to ensure better employment opportunities within OH. Respondents of the questionnaire perceived that students with OH education had improved employability across the spectrum of employment opportunities; however, there were still instances where respondents indicated employment was more difficult after OH education (Fig. S3, Supplementary Material). If students graduate with consistent skills that allow them to have the necessary technical

and cross-cutting competencies to work in OH, it is more likely that they can be employed within their technical field but also within OH more broadly (Frenk *et al*., 2010; Togami *et al*., 2023).

While respondents regularly reported the need for more or expanded OH education across many disciplines (Tables 2 and 3), they also indicated the time to make new materials ranges from half a year to one and a half years depending on the length and qualifications the program results in. This process is not only time-consuming but requires substantial human and financial resources (Fig. S2, Supplementary Material). Benchmarks for OH education could assist in reducing some of the time to design OH education. Our results on resource requirements are supported by previous studies that noted barriers such as insufficient expertise, knowledge, and course content, as well as difficulties in technical teaching, and a lack of essential resources such as leadership, time, training opportunities, equipment, and budget for the curriculum change (Turnwald and Walkington, 2009; Lerner and Berg, 2015).

Limitations of this study include a non-response bias with a total 46% response rate from all those nominated to participate. Non-responses likely limited the ability to understand the breadth of programs on offer, and opinion data could differ between respondents and non-respondents. Aside from Mozambique, it is difficult to determine the characteristics of non-respondents compared to respondents. Mozambique's non-response could be due to language barriers and future studies should consider implementation in multiple languages. Additionally, implementation through qualification authorities such as the IUCEA for a regional authority, for example, the Kenya Institute of Curriculum Development as a national authority, could also increase response rates.

In conclusion, higher education institutes in Eastern and Southern Africa have clearly indicated the importance of OH within their institutions given the breadth of programs, courses, and community education opportunities, both currently in place and desired for future implementation. The implementation of OH education in Eastern and Southern Africa is currently limited by lack of institutional, national, and regional benchmarks and frameworks for OH education at all levels. Technical fields focus on OH competencies from within their own sector, when there needs to be greater emphasis on cross-cutting competencies that suit all sectors of OH. Lack of frameworks and clarity, and insufficient time and resources limit cohesive implementation of OH education. To improve OH education in Eastern and Southern Africa, there must be greater transparency and awareness about what OH education is on offer (via a shared database for example), and what competencies are core to programs and courses focused on OH, with consideration for the great breadth of technical areas needed within the OH sphere. Regional bodies like the IUCEA and the Southern African Regional Universities Association (SARUA) can continue to share regionally appropriate best practices and benchmarks for programs, and international entities like the quadripartite can develop similar internationally-based OH competency frameworks through their OH-JPA. While competency frameworks and transparency of available OH education are of importance, it will be up to countries and educational institutions across all levels of education to take on the challenge of integrating OH in a comprehensive and consistent manner, and this will be a great challenge unless appropriate resources are mobilized.

CONFLICT OF INTEREST

The authors declare that they have no competing interests

ETHICS STATEMENT

Ethical approval for conducting the study was obtained from the Institutional Research Ethics Committee (IREC) of International Livestock Research Institute (ILRI) before commencement of the study, approval ILRI-IREC2022-20/3. Similarly, formal informed consent was obtained beforehand from each respondent.

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AUTHOR CONTRIBUTIONS

BYW, SR, DG, TKJ, and FM conceptualized the project; IM and FM contributed in data curation; FM handled formal analysis; TKJ, FM, DG, AC, and HDN contributed in funding acquisition; BYW Investigated the data; BYW, SR, DG, FM, and NQ contributed in methodology; BYW, SR, IM, FM, DG, TKJ, AC, HDN, EK, MK, BG, and YT administrated the project; SR, DG, FM, and TKJ supervised the study; FM visualized the study; SR, FM, and BYW contributed in writing; and BYW, SR, DG, TKJ, FM, IM, AC, HDN, EK, MK, BG, and YT contributed in writing review and editing.

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DATA AVAILABILITY

Anonymized data can be made available upon request to the corresponding author.

SUPPLEMENTARY MATERIAL

The supplementary material is available in the online version of this article.

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