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Veterinary public health: veterinary medicine's current challenges in a globalised world

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Veterinary public health: veterinary medicine's current challenges in a globalised world

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Editorial: Veterinary public health: veterinary medicine's current challenges in a globalised world

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Editorial on the Research Topic
Veterinary public health: veterinary medicine's current challenges in a globalised world

1 Introduction

The transfer of zoonotic agents is a normal and well-known phenomenon. Every substance or living thing is a potential carrier, while a favorable environment increases the risk of transmission. As sources of zoonotic agents, all types of domestic animals are also in focus, whether working animals (including those used for sport), companion animals or pets, or animals reared for food production. The keeping or rearing of these animals is not uniform worldwide, as local culture plays a major role in local approaches to animals. Also, stray animals pose a global challenge in terms of their welfare and their role in the transmission of zoonoses.

Veterinary medicine (VM) has a major responsibility in preventing zoonosis transmission, with two main branches involved: clinical VM and preventive veterinary public health (VPH). Geographically, the profile of the veterinary profession is by no means uniform, as lifestyles in industrialized and developing countries differ. In developed countries, VM is frequently focused on companion animals, sometimes with tools and equipment close to those used in human medicine. Hence, the treatment of companion animals is highly regarded by the general public and the veterinary profession itself.

On the other hand, VPH is frequently associated with administration. However, VPH is much broader in scope than just an administrative service, as it deals with population and preventive medicine, progressive, modern food safety and animal welfare. VPH is responsible for the entire local animal population and must be adapted and adaptable to changing regional circumstances. Both interventions and solutions depend on the individual disease situation, and for successful measures, VPH is now based on complex horizontal, interdisciplinary solutions. Therefore, it is misleading to describe VPH only as a domain of legislation and administration. It is true that national and international legislation is the basis for appropriate structures and intervention procedures.

Building on this, however, VPH provides the capacity and interdisciplinary competence for intervention to keep a risk situation under control.

Local events sometimes have consequences on a broader geographical scale, reaching global importance. Today, information technology (IT) serves as a tool for immediate communication. For the first time in human history, with the help of IT, information about a disease now travels faster than the agent, promising good options for successful VPH interventions.

2 This Research Topic's focus

Contributions to this Research Topic come from the global south and north. Some contributions point to a lack of practical realization of ideas, e.g., animal agency (Ameli and Krämer) and antibiotic stewardship (Gunn-Sandell et al.), while others point to gaps in practical performance, e.g., the One-Health concept, which has been discussed for years, but still lacks practical implementation.

The contributions generally show that personal issues within the VPH profession are considered a major point of research. Indeed, VPH curricula in universities are a central means for the future development of concepts for our profession and a better understanding of VPH. Unfortunately, in industrialized countries, there is a lack of student interest in VPH, perhaps because of the safety of life in such countries. However, all VM students must learn the full scope of VPH, such as understanding the background and purpose of legislative interventions. Such in-depth knowledge is required for the smooth acceptance and implementation of legislation. Moreover, study courses for both undergraduates and postgraduates need to better utilize IT as an excellent tool for education and training on global VPH concerns. Finally, the One-Health concept must be established in the curricula of both human and veterinary medicine.

2.1 Animal welfare

Depending on geography and history, our attitudes toward animals can differ; call it the ethical line of society toward animals. Two papers discuss the animal welfare sector, raising the question of how we treat laboratory animals, stray dogs and stray cats. In the case of laboratory animals, Ameli and Krämer questioned the culture of care for them in Germany. The authors asked different experts from institutions across Germany about their position (regulators, managers, scientists, care persons) and received different answers, ranging from a high level of responsibility (care persons) to formal aspects (regulators), and awareness of the need to provide animal welfare (scientists). Managers emphasized the culture of care to a lesser extent.

To keep stray dogs and cats under control, an Ethical Population Management Program is in use on a university campus in Minas Gerais, Brazil. Bicalho et al. studied its efficacy and perceptions of campus users. The measures taken in the programme were widely endorsed.

2.2 Personnel and administrative issues

Diseases do not recognize borders, so contact between neighbors is a basic condition for successful veterinary measures. Auplish et al. analyzed the capability of veterinary field staff in Vietnam for disease prevention, preparedness and intervention. Vertically, training and competence were more limited at the district and commune level than at the national level. However, inequities were also found at the local level (horizontally).

The World Organization for Animal Health (WOAH) has compiled a list of competencies that veterinarians need in order to support national veterinary services, and Ethiopia has consequently implemented a new national curriculum. Bessler et al. identified barriers to its practical implementation: i.e., organization of veterinary services, inspection and certification procedures, practical application of the regulatory framework for disease prevention and control, lack of teaching and training materials and financial constraints.

Nyokabi, Phelan, et al. addressed infection/zoonosis control and biosecurity measures among VM students in Ethiopia. VM students were aware of the public health risks posed by zoonoses and of the important role of cooperation between human and veterinary medicine. However, the students showed poor knowledge of infection control measures and biosecurity or even measures to reduce occupational risks. The authors stressed the importance of students' access to information about the risks of zoonoses, infection control and biosecurity measures, which could also affect the way veterinarians themselves behave in the event of a zoonotic disease.

In this sense, Hoet et al. presented guidance for VM educational institutions to improve curricula in VPH and population medicine. Students should be able to respond to the challenges from day one of their professional life. The blueprint was a standard curriculum developed by the WOAH (see also Bessler et al.).

Nyokabi, Wood, et al. investigated veterinarians' knowledge and VPH competence in relation to cattle disease symptoms in Ethiopia. They were able to identify such diseases, but the authors found gaps when it came to the consequences in the field of VPH.

The general issue of personal pressure during one's occupational life should always be taken into consideration. Neubauer et al. surveyed all registered veterinarians and VM students in Austria. Administration, animal suffering and different forms of communication with animal owners were the most burdensome pressures for working veterinarians. VM students were already aware of the coming occupational stress; however, they anticipated other stressors than those reported by their working colleagues.

2.3 Antimicrobial resistance

For many years, antimicrobial resistance has been a major point of interest within VPH. Lekagul et al. described the Voluntary Optimization of Antimicrobial Consumption (VOAC) programme in Thailand. Antimicrobial resistance concerns not only food animals, as resistance can also start from companion animals. Gunn-Sandell et al. investigated the knowledge of

antimicrobial drug use and resistance among veterinary clinic support staff. The authors presented an Antibiotic Stewardship Program, i.e., protocols, programmes and other materials that promote appropriate antibiotic use. Antimicrobial resistance was well-known, while antimicrobial stewardship was underestimated.

2.4 Surveillance of food animals

In addition to traditional meat inspection, which was established a long time ago, the whole food chain approach to meat production was triggered by the BSE disaster in the 1990s. This modern approach is now well established and provides information on the history of an animal or a herd. However, when such information is unavailable, inspection procedures for food animals depend on local circumstances and specific situations. Bekele Atoma et al. conducted a study on small ruminants in the Ethiopian Highlands, where food chain information was not available. Therefore, traditional inspection at the abattoir was applied. The authors concluded that the reduction of the parasite burden and improved handling could increase the profitability of the small ruminant meat sector in Ethiopia.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Advancing One Health through veterinary education: a mixed methods needs assessment for implementing a WOAH-harmonized national veterinary medicine curriculum in Ethiopia

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Introduction: International organizations now actively promote and implement One Health collaborative approaches to prevent, detect, and control diseases in humans and animals, recognizing the critical importance of the veterinary and agricultural sectors. Moreover, Veterinary Services are chronically under-resourced, especially in low- and middle-income countries. Given the importance of National Veterinary Services to food security, nutrition, poverty alleviation, and global health security, strengthening veterinary capacity is a priority for the international community. The World Organisation for Animal Health (WOAH) outlines a set of minimum competencies veterinarians need to support National Veterinary Services effectively. To improve the quality of veterinary education, Ethiopia has developed a new 2020 national curriculum that is harmonized with the WOAH competencies.

Methods: A mixed methods needs assessment was conducted to identify barriers and challenges that Ethiopian veterinary medicine programs have faced in implementing the new WOAH-harmonized national curriculum. Representatives from active veterinary programs granting a Doctor of Veterinary Medicine (DVM) degree were invited to share their experiences via an online survey and follow-up focus group discussion.

Results: Fourteen veterinary programs, representing 93% of eligible programs nationwide, participated in the needs assessment. Quantitative analysis indicated that the most difficult topics associated with the new curriculum included Organization of Veterinary Services (Competency 3.1), Inspection and Certification Procedures (3.2), and practical applications of the regulatory framework for disease prevention and control (multiple competencies). Challenges associated with specific instructional methodologies, particularly the facilitation of off-site (private and public sector) student training, were also perceived as barriers to implementation. Focus group discussions elucidated reasons for these challenges and included limitations in faculty expertise,

resource constraints (e.g., supplies, infrastructure), and access to off-site facilities for hands-on teaching.

Conclusion: The results of this needs assessment will be used to identify and prioritize solutions to implementation challenges, helping Ethiopian veterinary medicine programs move the new WOAH-harmonized curriculum from theory to practice. As veterinarians are integral partners in advancing One Health, strengthening the capacity of Veterinary Services can ultimately safeguard animal and human health, grow economies, and improve lives.

KEYWORDS

capacity building, needs assessment, veterinary services, education, One Health

Introduction

The world's population has grown exponentially in recent history and is projected to grow from 8 billion worldwide currently, to 9.7 billion by 2050 (1). As the world's population continues to grow, so too does the demand on agricultural sectors, including food animal production where countries' Veterinary Services help to support the food system, protect animal (and human) health, and promote countries' agricultural economies. For example, Ethiopia's population is expected to reach 205 million by 2025 from its current size at approximately 120 million (1). As a consequence, existing pressures on the agricultural system such as land scarcity, insufficient agricultural technologies, and inaccessibility of pastoral livestock farmers to animal health and veterinary services are exacerbated, making it more difficult to feed the growing population (2, 3). Furthermore, there are many threats to human and animal health around the world that encourage the emergence of infectious diseases and impact food security, including climate change, habitat modifications, broadening vector ranges, and human behaviors, among others (4–8). Low- and middle-income countries (LMIC), particularly in Africa, bear a higher disease burden and experience greater consequences of climate change (9, 10). By way of illustration, Ethiopia continues to experience more frequent and severe droughts, erratic rainfall in a country reliant upon predominantly rain-fed agriculture and persistently higher temperatures leading to heat-stress on humans and animals. These climate-related changes lead to secondary consequences such as increased occurrence and rages of vector-borne (e.g., Dengue, leishmaniasis, malaria), water-borne (e.g., rotavirus), and zoonotic (e.g., leptospirosis, Q fever, trypanosomiasis) diseases (10, 11). Thus, more strain is placed upon Ethiopia's and other countries' Veterinary Services, which are already beleaguered by limited resources and shortages of skilled personnel to respond to and manage contagious diseases and oversee food systems. Ameliorating these countries' Veterinary Services is an important step for decreasing disease burdens and increasing livestock production in developing countries.

Many initiatives and programs have been instituted to address these challenges, principally focused on veterinary curricula and related training programs through a One Health lens in Africa, including Ethiopia (12–16). A few of the organizations that are involved in leading or supporting training programs or curriculum development for veterinary service professionals are the Centers for Disease Control and Prevention (CDC), the Food and Agriculture Organization of the United Nations (FAO), the United States Agency for International Development (USAID), the World Bank, and the World Organisation for Animal Health (WOAH) (17–20).

The Veterinary Education Twinning Program, sponsored by WOAH, provides an example of this targeted work. In 2015, a partnership between The Ohio State University College of Veterinary Medicine (OSU-CVM) and the University of Gondar College of Veterinary Medicine and Animal Science (UoG-CVMAS) in Ethiopia was forged. This Twinning Program involved a curriculum assessment, as well as faculty and student development through exchanges and continuing education training (21). These activities culminated in the development and implementation of a UoG-CVMAS curriculum aligned with the *WOAH recommendations on the Competencies of graduating veterinarians ('Day 1 graduates') to assure National Veterinary Services of quality* and the *Veterinary Education Core Curriculum* (22, 23). The newly developed UoG-CVMAS WOAH-harmonized curriculum contained all 11 specific and 8 advanced competencies, covering topics including epidemiology, transboundary animal diseases, zoonoses (including foodborne diseases), animal welfare, and food safety, among others. This new, WOAH-harmonized curriculum, the first of its kind in Africa (21), was launched in September 2017 and was intended to strengthen Ethiopia's Veterinary Services by graduating veterinarians ready to support their country's services.

Ethiopia's Ministry of Education (MoE) reviews and updates the national veterinary medicine curriculum every 10 years, creating in 2019 a *National Curriculum Task Force* to lead such process. The Deans and representatives of all Veterinary Education Establishments (VEEs) in Ethiopia and other stakeholders (including the veterinary association) integrated this task force. This working group agreed to use the UoG-CVMAS WOAH-harmonized curriculum as the benchmark for the new national curriculum, approving and deploying the new academic program for implementation by all Ethiopian VEEs in November 2020.

Abbreviations: CDC, U.S. Centers for Disease Control and Prevention; DVM, Doctor of Veterinary Medicine; FAO, Food and Agriculture Organization of the United Nations; FGD, focus group discussion; LMIC, low- and middle-income country; MoE, Ministry of Education; OSU-CVM, The Ohio State University College of Veterinary Medicine; SNNPR, Southern Nation, Nationalities, and People's Region; UoG-CVMAS, University of Gondar College of Veterinary Medicine and Animal Sciences; USAID, United States Agency for International Development; VEE, Veterinary educational establishment; WOAH, World Organisation for Animal Health.

Introducing a new, nationwide professional curriculum is complex in any setting and was expected to be especially challenging in Ethiopia because of regional variability in access to resources and personnel capacity. These challenges were compounded by recent events, including the COVID-19 pandemic and armed conflict in some regions, that further disrupted educational systems and communications (24–26). It is critical to identify and address the barriers and challenges that Ethiopian VEEs are facing in implementing the new national curriculum to graduate veterinarians who can respond to emerging disease threats, protect the food system, and strengthen Ethiopia's agricultural economy. Therefore, the methodology described in this study uses a mixed methods approach to understand VEEs' experience of moving from theory to practice in implementing a new curriculum and identify specific difficult content and the barriers they face. While primarily focused on the national needs assessment process to identify such obstacles, the authors will briefly discuss the next steps. Following this study, the outcomes of the needs assessment will be presented for the prioritization of potential solutions for intervention and the development of an Action Plan to accomplish harmonization with the new curriculum nationally. This systematic process from the needs assessment to Action Plan will unite Ethiopian VEEs in the delivery of their veterinary programs and graduation of high-quality veterinarians, thus strengthening Ethiopia's veterinary services and, ultimately, advancing One Health.

Methods

Study design and data collection

We conducted a mixed methods needs assessment between June and November 2022 to evaluate the experiences with the adoption of the new 2020 national veterinary curriculum and identify the specific challenges that Ethiopian VEEs are facing during its implementation. The needs assessment consisted of two data collection steps: an asynchronous online questionnaire (quantitative) using Qualtrics^{XM} survey software and synchronous focus group discussions (qualitative) following survey completion. Our study followed a sequential explanatory design, in which the qualitative component sought to explain and provide further information about the quantitative results (27).

Study area and participation criteria

Situated in the Horn of Africa, Ethiopia is an LMIC with a population of over 120 million people (second highest in Africa) (28). Agriculture is critically important to the economy of Ethiopia, comprising over 30% of its gross domestic product (29). Formal training for supporting Ethiopia's growing agricultural sector is provided by its many universities, whose educational structure is governed by the MoE. The universities included in this study are located throughout Ethiopia, including Amhara, Afar, Oromia, Somali, and Southern Nation, Nationalities, and People's Region (SNNPR) (see Figure 1).

The needs assessment focused on those academic programs awarding a Doctor of Veterinary Medicine (DVM) degree, as one of Ethiopia's major personnel sources for the veterinary services workforce. All active VEEs offering a DVM degree were targeted for participation; however, very newly established VEEs (i.e., had not yet graduated a cohort of students or were unlikely to have experience with the new curriculum) were excluded from this assessment. At the time of the study, there were a total of 16 universities meeting the inclusion criteria of offering a DVM degree, 1 university was excluded due to its newly established status. Additionally, 1 eligible university was unable to participate due to conflict in their region. In total, 14 universities meeting the inclusion criteria were eligible and able to participate in the study.

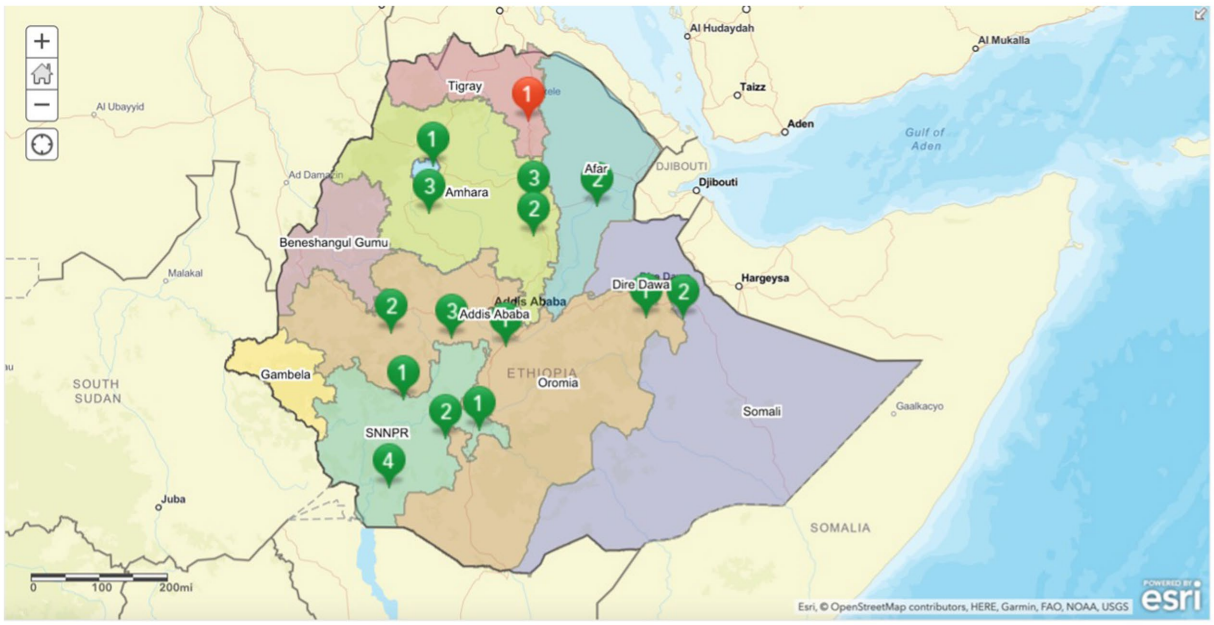

FIGURE 1
Map of participating (green) and non-participating (red) Ethiopian veterinary education establishments, including their generation number which is based on year of establishment.

Needs assessment development

Online survey

The *OSU-UoG Twinning Program Action Plan* (30) was used as a starting point for the development of the needs assessment survey (step 1 of this process), as it helped to identify much of the new content that was included in the new 2020 national curriculum and most likely to create implementation issues. The UoG-CVMAS team confirmed the changes to the national curriculum and identified other topics or elements incorporated during the national curriculum task force meetings. When all new content for the 2020 national curriculum was confirmed, the identified topics and themes were transformed into questions that aimed to characterize the difficulty of implementing each identified change.

The final stage of survey development (refinement) included an external review panel, formed by VEE deans from established veterinary programs (Hawassa, Jimma, and Wollo) who were also part of the national curriculum task force. Their feedback was sought to ensure the inclusion of all topics and changes made to the new national curriculum that would need to be implemented across the VEEs and therefore need to be assessed through the survey. This feedback was used to update and create the final version that was transferred to the Qualtrics^{XM} survey platform.

The survey aimed to collect data on four main areas: (a) VEE background information, including their general experience with the implementation of the new national curriculum, (b) the level of difficulty the VEE experienced implementing the new content related to WOAH Day 1 Specific Competencies, (c) the level of difficulty implementing the new content related to WOAH Day 1 Advanced Competencies, and (d) the level of difficulty implementing cross-cutting topics/program areas (e.g., One Health, student placements for off-campus training). Excluding the background section, the survey had 36 Likert-style questions, where options for responses included: (1) does not apply to our VEE, (2) very difficult, (3) moderately difficult, (4) moderately easy (5) very easy, and (6) not sure. The selection of "does not apply to our VEE" and "not sure" produced a secondary open-ended prompt for responders to elaborate on their reason for that selection. Similarly, if responders selected "very difficult" or "moderately difficult," a secondary prompt would encourage responders to indicate reasons for difficulty (multiple selections, including the option of 'other' with further specification). Selecting any response other than moderately easy or very easy would prompt further conversation during the focus group sessions.

Each participating VEE was tasked with assembling an internal "*survey team*" (discussed further below under *Needs Assessment Implementation*), which could include multiple faculty and/or administrators (Dean or Department Heads) who taught content related to WOAH Day 1 Competencies and/or participated in their 2020 curriculum implementation. Each VEE survey team was intended to both complete the online survey and participate in the focus group discussions.

Focus group discussions

Focus group discussions (FGDs) were designed to provide each VEE survey team the opportunity to elaborate or further explain their responses to the online survey. Individual FGDs were facilitated by members of the OSU-UoG team and conducted virtually using the Zoom platform (Version 5.13.11) with each VEE after they had completed the online survey. These confidential discussions were held in English and recorded to facilitate data collection and analysis. The FGD protocol was consistent for each VEE survey team (Table 1).

Needs assessment implementation

Needs assessment implementation involved a series of six steps: (1) recruitment, (2) preparation, (3) online survey completion, (4) preliminary analysis, (5) focus group discussion, and (6) data integration and final analysis. The recruitment step consisted of a webinar (June 1, 2022) which served to socialize the project with the deans of recruited VEEs, who learned about the purpose of the study, the methodology, and how the results would be used to strategize and prioritize interventions. At this time, deans were tasked with assembling their internal survey teams, so the next step, preparation (step 2), could begin. Once the VEE survey teams were assembled, individual virtual meetings took place (July 2022) to describe the study methodology, its objectives and purpose, and the survey question format to each team before receiving the survey. After these pre-survey preparatory meetings, VEEs received an email with the link to the online survey, as well as a PDF version of the survey to facilitate discussion before completing and submitting the online survey (step 3), should they wish to do so. As completed surveys were received (July–November 2022), the OSU-UoG team would conduct a preliminary analysis (step 4), highlighting the elements to be addressed in the FGDs (Table 1). FGDs were then scheduled (step 5) to provide the qualitative data for the needs assessment. The sixth and final step, with the completion of all FGDs, was data integration and analysis (step 6).

Data integration and analysis

All data were aggregated and anonymized, so no personally identifiable information was included in the analysis and presentation of results. Quantitative data management and descriptive statistics were conducted using Microsoft Excel (Version 16.73, 2023), while statistical analyses were performed using R statistical software (Version 4.2.2, 2022). FGDs were recorded and transcribed verbatim, using two auto-transcription services, Zoom (Version 5.13.11, 2023) and Mediasite (Version 8.16.0, 2023), with manual verification by the OSU-CVM team. Transcript correction, coding, and thematic analysis were performed using NVivo software (Version 20.6.2, QRS International) by multiple team members together (range: 2–4) to reduce confirmation bias. Coding was done inductively (31), utilizing the constant comparison method (32), while also listening to the meeting recordings to make any additional corrections to each transcript. Once the initial coding and thematic analysis process was complete, results were shared with the whole team (OSU-CVM and UoG-CVMAS) to discuss and validate the findings.

Ethical considerations

The Ohio State University Office of Responsible Research Practices has determined that the referenced research does not meet the federal definition of human subjects' research requiring review. Data was collected as part of a non-research quality improvement project, the analysis of survey data did not meet the federal definition

TABLE 1 Focus group discussion protocol for each Ethiopian veterinary education establishment participating in the needs assessment.

Element	Purpose
Meeting overview • Goals • Format	Review the objectives and purpose of the needs assessment and provide an overview and structure of the FGDs
Survey team introductions • Name • Role in the university (dean, lecturer, member of curriculum committee) • Classes/topics taught	Each member of the survey team identified themselves, their role in the needs assessment survey, and their role within the university to better understand their perspective and experience working with the new curriculum
Background information • Experience completing the survey • Experience with new curriculum	Describe the survey team's experience discussing the questions and incorporating each member's inputs Describe the VEE's experience with the new curriculum, including when/how it was received, guidance or instructions received, and how many years of implementation
Topics indicated "moderately difficult" or "very difficult" on survey	Review and describe topics considered difficult to implement; understand what barriers and challenges exist to warrant the difficulty
Prioritization of difficult topics	The survey team members selected and justified which identified difficult topics they would prioritize for intervention for their program
Points for clarification (e.g., does not apply, not sure)	Determine if any questions were unclear or if survey responses warranted review and further explanation
Topics indicated "moderately easy" or "very easy"	Review topics considered easy to implement; elaborate on pedagogical methods, teaching resources, other assets used/available that warranted this classification
Additional comments	Survey team members could ask additional questions or provide additional comments about implementing the new national curriculum or the needs assessment survey/process
Strategy and timeline	Provide overview of needs assessment methodology, how data will be used, and next steps to encourage transparency and continued participation

TABLE 2 Participating Ethiopian veterinary medicine programs, categorized by their year of establishment and generation.[a]

1st Generation (before 2003)	2nd Generation (2004–2011)	3rd Generation (2012–2017)	4th Generation (after 2017)
Addis Ababa University, College of Veterinary Medicine and Agriculture **University of Gondar**, College of Veterinary Medicine and Animal Sciences **Haramaya University**, College of Veterinary Medicine **Hawassa University**, Department of Veterinary Medicine **Jimma University**, College of Agriculture and Veterinary Medicine	**Jigjiga University**, College of Veterinary Medicine **Samara University**, College of Veterinary Medicine **Wolaita Sodo University**, School of Veterinary Medicine **Wollega University**, School of Veterinary Medicine **Wollo University**, School of Veterinary Medicine	**Ambo University**, College of Agriculture and Veterinary Science **Bahir Dar University**, School of Animal Science and Veterinary Medicine **Woldia University**, School of Veterinary Medicine	**Jinka University**, Department of Veterinary Science

[a]Year of establishment is based on when the university initiated its DVM granting degree program. Universities either have a separate college/school of veterinary medicine within their university or a department of veterinary medicine within their college/school of agriculture or animal science.

of human subjects' research, and currently only exists as de-identified data.

Results

Quantitative analysis

Fourteen (out of 15 eligible) VEEs participated in the needs assessment (both the online surveys and virtual FGDs) (93.3% response rate) (Table 2). Only one university, located in the Tigray Region, was unable to participate during the study period due to accessibility issues brought on by the armed conflict. A map indicating the participating VEEs, by generation number and region, is shown in Figure 1.

To quantify the survey results and identify the topics from the new 2020 curriculum that VEEs found most difficult to incorporate, a numeric value was assigned to the ordinal survey responses. For this purpose, a value of [4] was assigned to "very difficult," "moderately difficult" [3], "moderately easy" [2], and "very easy" [1]. Topics were also organized by their corresponding WOAH Day 1 Competency (Specific and Advanced) (Table 3) or cross-cutting topic/program area (Table 4), depending on their focus.

We also evaluated the association between the perceived difficulty of implementing certain topics and VEE generation. A total of four generations (first-fourth) of VEEs were categorized based on the year

their program was established (i.e., before 2003, 2004–2011, 2012–2017, and after 2017, respectively). The purpose of categorizing VEEs by generation was to identify if more senior institutions had less difficulty implementing the new curriculum than newer ones (Table 2). To do this, third- and fourth-generation veterinary academic programs were consolidated into one category and compared to first-generation and second-generation VEEs. An overall difficulty score was assigned to each VEE in which the percentage of survey responses indicated as "very difficult" and "moderately difficult" were calculated across all survey responses. Mean difficulty scores by VEE generation are presented in Table 5. Third- and fourth-generation VEEs had the highest mean difficulty rating, albeit not statistically different as compared to first- and second-generation VEEs detected/observed (Kruskal-Wallis, $p = 0.295$). There was also a wider distribution in difficulty scores for third- and fourth-generation veterinary programs compared to the first- and second-generation veterinary programs (Figure 2).

Qualitative analysis

Major themes were organized into three categories: challenges, neutral/mixed, and strengths. Common challenges with incorporating new content were organized under seven thematic areas: (a) barriers to practical (hands-on) training (12 VEEs mentioned), (b) facilities and infrastructure limitations (11 VEEs), (c) teaching materials shortage (11 VEEs), (d) national-level challenges (11 VEEs), (e) internal and external partnership challenges (11 VEEs), (f) faculty expertise limitations (10 VEEs), and (g) demanding logistics for off-site students training (10 VEEs). Two neutral/mixed themes emerged: curriculum alignment (12 VEEs) and geographical location of VEEs (8 VEEs). Program strengths were also highlighted in the FGDs, including partnerships (13 VEEs), faculty expertise in specific content areas (8 VEEs), and other miscellaneous strengths (e.g., existing practical experiences, access to equipment, and access to facilities) (5 VEEs).

Integrating quantitative and qualitative data allowed us to generate a summary of topics that pose the greatest implementation challenges to Ethiopian veterinary medicine programs, along with their respective WOAH Day 1 Competency (or cross-cutting/programmatic) areas. Additionally, specific barriers common to 70–85% of VEEs in the country were able to be elucidated in this analysis (Table 6). Securing external (off-site) training opportunities for students, either in the public or private sector, was a commonly perceived challenge. Some specific barriers mentioned included concerns about biosecurity, disruption of operations for the hosting institution/organization, and the security of the business practices of production facilities, particularly those in the private sector. Logistics and costs of moving students to off-campus locations were also mentioned. Another common challenge was the implementation of practical (hands-on) applications of course content. Specific competencies mentioned for this challenge were related to veterinary regulations for disease prevention and control (2.2, 2.3, 2.4), professional communications (2.11), risk analysis (3.5), veterinary ethics (2.9), preparation of health certificates (2.10), and diagnostic/therapeutic tools for disease prevention and control (2.2, 2.3, 2.4). The ten topics and themes with the greatest perceived difficulty are summarized in Table 6, along with illustrative examples from FGDs.

Discussion

Ethiopia is the first country in Africa to adopt a WOAH-harmonized veterinary curriculum to better train and equip the next generation of veterinarians who will directly support their National Veterinary Services to meet the growing needs of the country. Challenges exist, however, in moving from theory to practice in the implementation of this new curriculum across all VEEs in Ethiopia. This needs assessment identified several topics and "requirements" that have been difficult for VEEs to implement as part of their new 2020 national veterinary curriculum, as well as barriers hindering the incorporation of those topics. Among them, included the Organization of Veterinary Services (Competency 3.1), Inspection and Certification Procedures (Competency 3.2), and practical applications of the regulatory framework for disease prevention and control (multiple competencies). The FGDs expanded upon the perceived difficult topics and provided reasons for these challenges, including limitations in the facilitation of off-site (private and public sector) student training, faculty expertise on the subject matter as well as on preparing practical/applied content, resource constraints to support teaching and training (e.g., consumables, infrastructure), and access to off-site facilities for hands-on/practical teaching.

Furthermore, a commonly cited challenge acknowledged during the FGDs related to teaching materials shortage for training students. For example, some program representatives discussed challenges with the acquisition of personal protective equipment to conduct outbreak investigations, ante- and post-mortem examinations, and sample collection for infectious disease diagnostics. Others described challenges with shortages in medications, vaccinations, and other biologics used to teach their proper management and use. Similarly, significant deficiencies of laboratory materials for diagnostics, antimicrobial susceptibility testing, and veterinary product residue testing required to train future veterinarians are such important topics. Further inquiries during the FGDs identified various explanations for the materials shortages, primarily related to challenges associated with importing necessary materials into the country. While the process of supply procurement through the central government is often arduous and prolonged, financial constraints remain an enduring obstacle for veterinary programs to deliver practical or applied training. Other institutions and organizations in the region report similar challenges, citing a lack of access to adequate financial and material resources as a major impediment to One Health (33–35).

Beyond the procurement of necessary materials, financial constraints impart difficulties in implementing components of the new national curriculum, such as the organization and placement of students for off-site training. To appropriately respond to One Health issues including the frequent occurrences of disease outbreaks, antimicrobial resistance, food safety, and biosecurity, it will be critical for ministries and governmental bodies to provide access as well as establish financial and systemic support for One Health actions.

While primarily mentioned as challenges, internal and external partnerships were also cited as strengths for some programs. Many VEEs reported collaborating with other departments and colleges within their universities to fill gaps in subject matter expertise and gain access to facilities for diagnostics and laboratory techniques. For example, some programs partner with the College of Law to teach Ethics and Jurisprudence topics. Others indicated strong relationships

TABLE 3 Topics and their WOAH Day 1 competency ranked from the most difficult to least difficult.

Topic	WOAH Day 1 competency	Mean difficulty (SD)
Organization of veterinary services in Ethiopia	3.1—Organization of Veterinary Services	2.67 (0.745)
Practical application of the regulatory framework for disease prevention and control	2.2—Zoonotic (and Foodborne) Diseases 2.3—Transboundary Animal Diseases 2.4—Emerging & Re-Emerging Diseases	2.29 (0.699)
Inspection and certification procedures for exportation, including international import control mechanisms for animals and animal products	3.2—Inspection and Certification Procedure 3.7—International Trade Framework	2.29 (0.699)
Proper management and use of veterinary products (i.e., milk testing for drug residues)	2.7—Veterinary Products	2.21 (0.773)
Practical applications of professional communication skills	2.11—Communication Skills	2.21 (0.674)
Practical applications of risk analysis	3.5—Applications of Risk Analysis	2.21 (0.773)
Practical applications of the understanding and applications of high standards of veterinary ethics	2.9—Veterinary Legislation and Ethics	2.14 (0.914)
Practical applications of performing physical examinations for the preparation of health certificates for animal movement	2.10—General Certification Procedures	2.14 (0.833)
Practical applications of diagnostic and therapeutic tools for disease prevention and control	2.2—Zoonotic (and Foodborne) Diseases 2.3—Transboundary Animal Diseases 2.4—Emerging & Re-Emerging Diseases	2.14 (0.742)
Practical applications of the economic and public health implications (including international trade) of diseases	2.2—Zoonotic (and Foodborne) Diseases 2.3—Transboundary Animal Diseases 2.4—Emerging & Re-Emerging Diseases	2.07 (0.703)
Pre-harvest management practices and conditions	2.6—Food Hygiene	2.00 (0.655)
Topics related to the international trade framework (i.e., import control and implications of disease on international trade)	3.7—International Trade Framework	2.00 (0.961)
Practical applications of the regulations/standards for animal production, transport, and humane slaughter	2.8—Animal Welfare	1.93 (0.799)
Food safety topics related to drug residues	2.7—Veterinary Products	1.92 (0.917)
Practical applications of outbreak investigation and disease control	2.1—Epidemiology	1.86 (0.833)
Practical applications of disease recognition	2.2—Zoonotic (and Foodborne) Diseases 2.3—Transboundary Animal Diseases 2.4—Emerging & Re-Emerging Diseases	1.86 (0.833)
Performing animal welfare evaluations and outings	2.8—Animal Welfare	1.79 (0.860)
National veterinary legislation	2.9—Veterinary Legislation and Ethics	1.79 (0.773)
Appropriate and rational use of antimicrobial drugs regarding withdrawal times and drug residues	2.7—Veterinary Products	1.71 (0.699)
Mechanisms that lead to the development of antimicrobial resistance	2.7—Veterinary Products	1.64 (0.718)
Practical applications of the management of contagious diseases (including foodborne)	3.3—Management of Contagious Diseases 3.4—Advanced Food Hygiene	1.64 (0.610)
Topics related to the international trade framework (i.e., sanitary and phytosanitary procedures, WOAH, Codex Alimentarius)	3.7—International Trade Framework	1.62 (0.487)
Post-harvest good sanitary and management practices	2.6—Food Hygiene	1.57 (0.495)
Proper management of veterinary products (i.e., drug withdrawal times)	2.7—Veterinary Products	1.50 (0.627)
Veterinary legislation rules and regulations governing the veterinary profession in Ethiopia	2.9—Veterinary Legislation and Ethics	1.50 (0.627)
Hazard Analysis and Critical Control Point (HACCP)	2.6—Food Hygiene	1.43 (0.623)
Appropriate food hygiene, food storage, and food preparation	3.4—Advanced Food Hygiene	1.29 (0.589)
Theoretical concepts of risk analysis	3.5—Applications of Risk Analysis	1.29 (0.589)
Disease control applications of epidemiology concepts	2.1—Epidemiology	1.23 (0.421)
Harvest: antemortem examination, postmortem examination, and humane slaughter	2.6—Food Hygiene	1.21 (0.558)
Practical applications of research methodology	3.6—Research	1.21 (0.410)
Relocating the Animal Welfare course to be given earlier in the curriculum	2.8—Animal Welfare	1.14 (0.515)

Topics ranked by perceived difficulty by Ethiopian veterinary medicine programs ($n = 14$) on the online survey. Response categories ranged from "very difficult" = 4 to "very easy" = 1.

TABLE 4 Curriculum elements and their associated cross-cutting topic/program area.

Curriculum elements	Cross-cutting topic/program area	Mean difficulty (SD)
Student placement—private sector agencies	External training/student rotation	2.77 (0.799)
Biological waste management	One Health	2.38 (0.738)
Student placement—public sector agencies	External training/student rotation	2.31 (0.606)
Practical applications of One Health at the human-domestic-wild animal interface	One Health	2.21 (0.558)
Environmental health	One Health	2.21 (0.773)
Concepts and applications of a One Health Approach	One Health	1.79 (0.674)
One Health for emerging/re-emerging zoonotic disease prevention and control	One Heath	1.71 (0.452)
One Health for food safety and food security	One Health	1.71 (0.589)

Curriculum elements ranked most difficult to least difficult to implement, as perceived by different Ethiopian veterinary medicine programs ($n = 14$). Response categories ranged from "very difficult" = 4, to "very easy" = 1.

TABLE 5 Summary statistics for the degree of difficulty incorporating new topics based on the VEE generation.

Range of Individual VEE difficulty scores	Overall difficulty score	First-generation VEEs ($n = 5$) difficulty score	Second-generation VEEs ($n = 5$) difficulty score	Third- and fourth-generation VEEs ($n = 4$) difficulty score
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
40	21.2 (12.4)	20.9 (8.56)	15.6 (7.21)	28.1 (17.1)

The degree of difficulty is calculated as (% of questions indicated "very difficult" or "moderately difficult"); higher scores correspond to higher perceived difficulty.

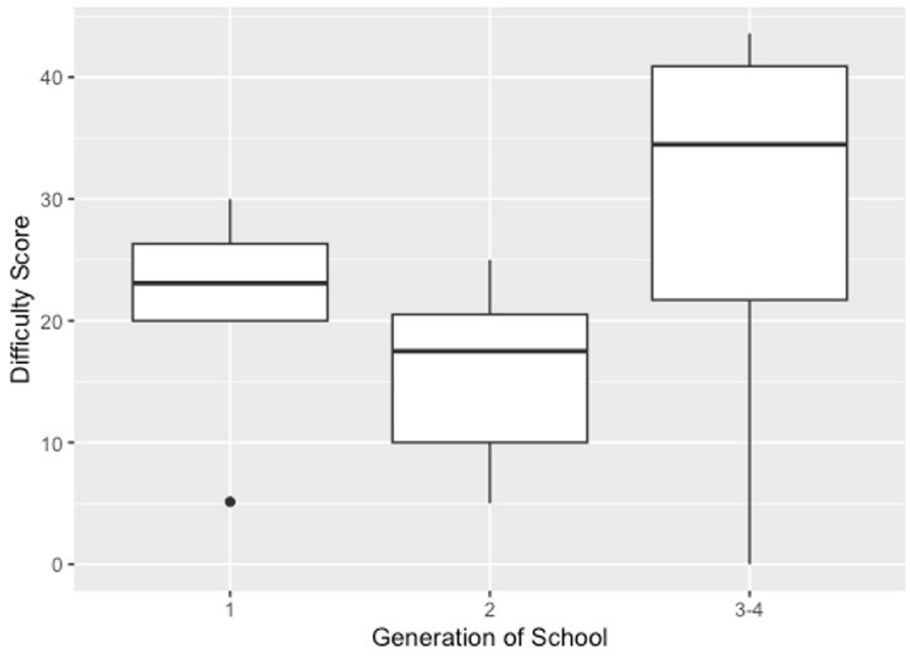

FIGURE 2
Box plots demonstrating the distribution of difficulty for incorporating certain topics into the new curriculum. Degree of difficulty is calculated as the % of questions indicated 'Very Difficult' or 'Moderately Difficult'; higher scores correspond to a higher perceived difficulty.

with off-campus partners, such as abattoirs, which provided opportunities for hands-on learning and student placements for externships. These relationships varied greatly by location based on regional resource availability. Most programs reported facing challenges in securing partnerships, particularly for student placements to engage in external training in the public and private sectors. Some programs compensate for a lack of opportunities for student placements through partnerships with other universities with greater access to regional laboratories and services or with international non-governmental organizations. These results correlate with similar findings that indicate a growing need for capacity building through collaborations with national ministries, international agencies, public-private partnerships, academic institutions, One Health networks, and donor organizations (36–39).

TABLE 6 Integrated results from quantitative and qualitative data listing the ten most difficult topics to incorporate.

Topic	WOAH Day 1 competency or cross-cutting topic/ program area	Mean difficulty (SD)—quantitative data	Theme(s) -qualitative data (n = the total number of Ethiopian veterinary medicine programs that commented)	Example from focus group discussions (VEE indicated by the number in which their FGD occurred chronologically)
Student placement—private sector agencies	External training/ student rotation	2.77 (0.799)	Partnership challenges ($n = 11$) Moving students for off-site training ($n = 10$)	"[Partnership] in the private sector…an example of the dairy farms, they do not want their animals to be disturbed. They do not want the farm to be disturbed for biosecurity reasons. They do not want to disclose also their operations, how the business works and all these things. So because of this reason, we are having difficulty [placing] students in the private sector." [FGD3]
Student placement—public sector agencies	External training/ student rotation	2.31 (0.606)	Partnership challenges ($n = 11$) Moving students for off-site training ($n = 10$)	"Every year we communicate [with] different organizations, the main organizations that accept our students is the Ministry of Agriculture, where the Veterinary Services is, and especially its regional Veterinary service institutions. We communicate with the research institutes, and also regional laboratories. We write letter to the different labs where we get some response [but]. sometimes when we do not get that response, then we have to change the place" [FGD14]
Practical application of the regulatory framework for disease prevention and control	2.2—Zoonotic (and Foodborne) Diseases 2.3—Transboundary Animal Diseases 2.4—Emerging & Re-Emerging Diseases	2.29 (0.699)	Barriers to practical (hands-on) training ($n = 12$) National level challenges ($n = 11$) Faculty expertise limitations ($n = 10$)	"From the faculty's perspective, we lack still a practical skill [of] how to do [conduct] diagnostic model for [teaching]. I think this is also a major gap in most of the faculties [veterinary schools]." [FGD1]
Inspection and certification procedures for exportation, including international import control mechanisms for animals and animal products	3.2—Inspection and Certification Procedure 3.7—International Trade Framework	2.29 (0.699)	National level challenges ($n = 11$) Faculty expertise limitations ($n = 10$) Curriculum alignment ($n = 12$)	"[…]our countries are all importing to the Middle East. [We] never export trade animal products, to Europe and Western countries because we do not have policy [for] disease eradication. We have a number of endemic animal diseases. So we are having a problem with the ability to export. And the Ministry of Agriculture, I think they are focusing to provide these certificates. And with this competency is very important for our students so that they will be skilled so they can help our nation in this certification of health, the herd level or the slaughterhouse, or our live animal export. That's very important but challenging one as we do not have this policy of implementation with drug residue, biological management [only] is theory, but it should be a combined with a practical one." [FGD10]
Proper management and use of veterinary products (i.e., milk testing for drug residues)	2.7—Veterinary Products	2.21 (0.773)	Facilities & infrastructure limitations ($n = 11$) Materials shortage ($n = 11$) Faculty expertise limitations ($n = 10$) Moving students for off-site training ($n = 10$)	"We did not have the facility to test veterinary product […] testing veterinary product for residues may be difficult." [FGD8]
Practical applications of professional communication skills	2.11—Communication Skills	2.21 (0.674)	Barriers to practical (hands-on) training ($n = 12$) Faculty expertise limitations ($n = 10$)	"Actually, on the communication skill, most of the time when we say communication skill, our focus is on language." [FGD5]
Practical applications of risk analysis	3.5—Applications of Risk Analysis	2.21 (0.773)	Barriers to practical (hands-on) training ($n = 12$) Faculty expertise limitations ($n = 10$)	"We teach the basic risk analysis methods, but we lack the application part. So application of risk analysis is very important and I think that faculty training is also very important in how to analyze risks, how to estimate and apply this case. It needs some sort of training for faculties" [FGD1]
Practical applications of the understanding and applications of high standards of veterinary ethics	2.9—Veterinary Legislation and Ethics	2.14 (0.914)	Barriers to practical (hands-on) training ($n = 12$) Faculty expertise limitations ($n = 10$)	"Veterinary Ethics and jurisprudence have been delivered by staffs with no specialization [in] this area, just it is a matter of experience. It is point raised by the school about who delivered this course so far, who has experience teaching in this area. But the person in charge [does not have] qualification in veterinary ethics and welfare unless delivering the course theoretically" [FGD2]
Practical applications of performing physical examinations for the preparation of health certificates for animal movement	2.10—General Certification Procedures	2.14 (0.833)	Barriers to practical (hands-on) training ($n = 12$) Curriculum alignment ($n = 12$) National level challenges ($n = 11$) Faculty expertise limitations ($n = 10$)	"Within the country as there is very little animal movement control. But for export purposes, there are either at postgraduate level or in the short-term training after graduation, people will get certification [training]. So after getting three months or six months training, they engage in this duty, especially with export animals. And the same is true for export abattoirs and also for the domestic abattoirs." [FGD14]
Practical applications of diagnostic and therapeutic tools for disease prevention and control	2.2—Zoonotic (and Foodborne) Diseases 2.3—Transboundary Animal Diseases 2.4—Emerging & Re-Emerging Diseases	2.14 (0.742)	Barriers to practical (hands-on) training ($n = 12$) Partnership Challenges ($n = 11$) National level challenges ($n = 11$) Facilities & infrastructure limitations ($n = 11$), materials shortage ($n = 11$), faculty expertise limitations ($n = 10$), and moving students for off-site training ($n = 10$)	"I think there are crosscutting problems across the universities in the veterinary college pertaining to laboratory capacities in general, including source of diagnostic capacities and other major instruments for animals to do the clinical examinations. The other thing is it might be different location wise. Like students in our case, they are going out for the clinical specialty, the fourth and the fifth-year students, they are going to the clinic and the clinic [does not] have a microscope. The only thing that they do is simply based on outward signs and some physical clinical parameters as they do their diagnosis and decide the treatment without actually considering the drug withdrawal time, without considering any other drug resistance and related issues. So that makes the veterinary training very difficult. We do not have local capacities. The veterinary clinics and regional laboratories around the university are not very much well-equipped." [FGD3]

Some of the survey result interpretations could have been impacted by deviations in the application of the surveys from the original study design. The surveys were intended to be completed by an internal survey team, representing and incorporating multiple perspectives and opinions from faculty and/or administrators; however, some survey submissions indicated a limited number of team members (the average survey team representation was 4 members, range: 1–8 members). This disparity of survey team compilation among participating VEEs could have introduced response bias in the interpretation of the quantitative results. It is possible that the surveys did not correctly identify all the difficult topics associated with the implementation of the new curriculum. However, the study design followed a mixed methodology to minimize the bias expected from individuals conducting the surveys alone. By facilitating the focus group discussions, the study aimed to capture multiple perspectives from representatives of the veterinary program who might not have been part of the initial survey team. Due to constraints of the COVID-19 pandemic and ongoing conflict in regions of the country, the ability to moderate the two study components (survey and FGDs) in person was impeded. Future studies employing this methodology should consider implementing in person moderation of the survey and FGDs whenever possible. This would help ensure the survey teams are constructed as intended and participation in both the survey and FGDs are implemented as intended to reduce response bias in either component. However, ultimately employing a mixed methods approach helps to cover gaps that either of the needs assessment components might have included in their individual application.

Similarly, the intent for the focus groups was established to encourage the group of representatives to talk with the study team and each other about their individual and shared experiences with implementing the various topics of the new 2020 national curriculum (40). However, this was not always possible because of scheduling conflicts and technology issues. This resulted in some FGDs having more limited participation and functioning more closely to a semi-structured interview, in which one or a limited number of representatives were able to participate and respond to each of the predetermined set of open-ended questions asked by the study team (41). This contrasted with our intended FGD study design, in which we hoped to provide a more open forum for representatives to freely discuss their opinions and perspectives. The shift of some of the discussions to a more semi-structured interview style might have prevented some participants from sharing their unique perspectives in front of a higher-ranking colleague. In the future, these limitations could be reduced and corrected by conducting FGDs in person to help ensure full survey team attendance and participation, help to better moderate discussions between members, and decrease constraints from technology interruptions.

Additionally, the survey results may be biased in the positive direction. Veterinary medicine programs often indicated on the survey that topics were "moderately easy" or "very easy" to implement, however during the FGDs, it was clarified that these topics are primarily being instructed at the theoretical level without practical application. This discrepancy in responses between surveys and FGDs highlight the importance of a mixed methodology in which responses can be as comprehensive as possible. However, a positive skew in survey responses might not have exposed important content that was more difficult to implement in reality, and implementing in-person moderation of surveys and FGDs would help to limit the discrepancy. Other recommendations for future studies to avoid this discrepancy and type of bias include making survey questions as short and clear as possible, avoiding leading questions, and keeping questions neutral. An example of this occurred when most programs indicated that while they teach epidemiological concepts (e.g., outbreak investigation), diagnostic techniques, and food safety topics, these lessons primarily occur in the classroom in the traditional didactic style (mostly lectures). However, to produce skilled and competent veterinarians, these academic programs lacked the incorporation of practical (hands-on) training for these topics and techniques. Depending on the veterinary program, this gap in training might be due to a lack of faculty expertise on the subject or a lack of facilities or materials to conduct training. These findings are similar to challenges identified in a previous study detailing the need for capacity building to address challenges with responding to infectious diseases in low-resource settings. Specifically, Gebreyes et al. recognized the need for standardized curricula within the One Health framework to increase the number of skilled and educated personnel, as well as the development or improvement of diagnostic laboratories as a key component of any disease surveillance, control, and prevention system (42).

An expected outcome of the needs assessment was that third and fourth-generation VEE would report greater difficulty (both in the number of topics and perceived difficulty), as they have less experience in program delivery and likely more junior faculty. However, quantitative results did not differ statistically between "older" and "newer" veterinary programs. The results did reveal a broader distribution of scores for third- and fourth-generation programs, indicating greater variability (and possibly less certainty) of responses. As newer programs gain experience in course delivery and administration, we may anticipate more consistency in the reported difficulty levels and topics, as was noted for the more established (first- and second-generation) programs.

Ultimately, the needs assessment is the first component of a larger project that seeks to help veterinary medicine programs across Ethiopia fully implement the new WOAH-harmonized national curriculum. In the next phase of this project, the identified difficult content and themes, along with the barriers recognized in the needs assessment will be presented at a multi-stakeholder national workshop. In this two-day event, participants will discuss and prioritize potential innovative solutions to the challenges identified in this needs assessment. These solutions might include faculty exchanges and continuing education, coordination of a VEE liaison with public and private organizations to improve student access and materials acquisition, or the formation of a VEE online community to exchange resources and teaching methodology similar to a community of practice framework (43). Workshop outcomes will be summarized in a comprehensive Action Plan for VEEs to consolidate the national curriculum. More information on the development and application of the workshop and its outcome will be described in a forthcoming manuscript. Nonetheless, the final product of an Action Plan is ultimately meant to support the national strategy for veterinary medicine training in Ethiopia. Ensuring that VEE programs provide a comprehensive curriculum in which veterinary graduates have received not only important foundational didactic content but also opportunities for the practical application of important topics they will apply in their roles upon graduation is necessary for the future of

the veterinary workforce in Ethiopia. Successful incorporation of the WOAH Day 1 Competencies by all veterinary programs across Ethiopia incorporates a One Health approach that will help strengthen the country's Veterinary Services, which ultimately improve animal and human health outcomes.

Conclusion

This mixed methods needs assessment methodology identified some of the various challenges and barriers that Ethiopian veterinary medicine programs face in implementing their new 2020 national veterinary curriculum. The new veterinary medicine curriculum has been harmonized with the WOAH Day 1 Competencies for graduating veterinarians that are established to support the veterinary services of each country. It is important to support and enhance countries' Veterinary Services as they respond to emerging/re-emerging and transboundary animal diseases, threats to food systems, and environmental changes that increase the prevalence of zoonotic diseases that have impacts on human and animal health. Therefore, enhanced capacity building and collaborations, along with strong governmental support will be necessary for LMICs, including Ethiopia, to adapt and respond to threats against animals, humans, and the environment.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

ALB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing – original draft, Writing – review & editing. AH: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. SN: Data curation, Investigation, Methodology, Writing – review & editing. SS: Data curation, Formal analysis, Investigation, Methodology, Writing – review & editing. TF: Investigation, Methodology, Supervision, Writing – review & editing. BA: Data curation, Investigation, Methodology, Writing – review & editing. AM: Data curation, Investigation, Methodology, Writing – review & editing. MB: Data curation, Software, Writing – review & editing. AMB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Stress factors in veterinary medicine—a cross-sectional study among veterinary students and practicing vets in Austria

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Background: Although the issue of high mental health burden among veterinarians is well-documented in previous studies, little is known about the specific occupational stress factors associated with mental health issues. Therefore, the aims of this study were twofold: (1) to assess occupational stress factors within the veterinary profession, with a particular emphasis on comparing the expectations of veterinary students with the experiences of practicing veterinarians and (2) to link the experienced stress with mental health indicators in veterinarians.

Methods: All registered veterinarians and veterinary-medicine students in Austria were invited to participate in a cross-sectional online survey. The data collection took place during the winter of 2022/2023 and included standardized questionnaires on mental well-being (WHO-5), depression (PHQ-9), anxiety (GAD-7), stress (PSS-4), and insomnia (ISI-2). Additionally, participants were asked about various estimated (students) or experienced (vets) occupational stress factors, which were to be rated on a 5-point Likert scale ranging from "not at all" to "very strongly". An open question invited respondents to identify in free text further experienced/anticipated sources of work-related stressors in veterinary practice.

Results: A total of 430 students and 440 veterinarians participated in the study. The results of a repeated measures analysis of variance (ANOVA) indicate that the burden of bureaucracy is perceived as less stressful by students than experienced by veterinarians, all other areas are perceived as more stressful by students than by veterinarians. In veterinarians, bureaucracy is experienced as the most burdensome, followed by animal suffering, and communication with animal owners. Further analysis of possible associations between the extent of perceived stressors and indicators of mental health shows that while bureaucracy is the most burdensome, it has the smallest correlation with mental health indicators. On the other hand, financial concerns, which are not ranked among the main stressors, have the strongest correlation with impaired mental health.

Conclusion: The results suggest that financial security for veterinarians is crucial to safeguard their mental health. The training of veterinary medicine students

and practicing veterinarians in the areas of administration, time management, handling animal suffering, and communication with animal owners might be beneficial in reducing their job-related stressors.

KEYWORDS

veterinarians, stressor, mental health, financial concerns, veterinary students

1 Introduction

Veterinary medicine encompasses diverse responsibilities, including medical care for companion animals, ensuring the health and well-being of production animals, and contributing significantly to public health (1, 2). Veterinarians work in diverse settings, from clients' homes, farms, or zoos/aquaria to laboratories, small practices to large clinics, public authorities and slaughterhouses (3). At the heart of their profession lies the care and welfare of various animal species, with veterinarians serving as primary healthcare providers for non-human patients (2) and playing a pivotal role in preventing and controlling zoonotic diseases and ensuring food safety (4). This multifaceted profession demands a continual pursuit of clinical knowledge and skills, underpinned by a strong ethical framework that guides human-animal interactions, emphasizing respect and accommodation for the abilities, interests, and economic circumstances of animal owners. However, this profession faces challenges, including occupational stressors that impact the mental health (5). Recognizing and addressing mental health within the veterinary community is crucial due to the demanding nature of their responsibilities.

The issue of high mental illness burden among veterinarians is well-documented in previous studies (5–7). A recently published study from Austria reported that both male and female veterinarians are the only highly educated professional group with a higher suicide rate than the general population (8). Our companion studies show that Austrian veterinary students and veterinarians experience worse mental health than the Austrian general population (9, 10). General risk factors identified in both samples were female gender, (desired) specification in small animal medicine, physical inactivity, and high smartphone usage. In the practitioners, mental illness symptoms were associated with younger age, higher working hours and fewer years in the profession, and the perceived stresses of euthanasia and perceived stress of working overtime were associated with higher suicidality (11). However, little is known about the specific occupational stress factors associated with mental health issues. Therefore, the present study expands upon the previous investigations by shedding light on the occupational stressors that are specific to the veterinary profession.

Existing research has focused on various stressors encountered by veterinarians, ranging from work-overload and client interactions to management responsibilities. These stressors have been studied in different regions, such as Belgium, Germany, the United Kingdom, the United States, and New Zealand (5, 12–17). Studies consistently reveal the high levels of stress experienced by veterinarians in their profession. Research has highlighted the prevalence of stressors such as workload, client interactions, ethical dilemmas, administrative tasks, financial worries, gender dynamics, and the physical and emotional impacts of the job (5, 12, 15, 17–19). More specifically, the studies have observed frequent overtime, weekend shifts, and work overload as major stressors in the profession (5, 12–16). The challenges associated with dealing with clients, encompassing communication difficulties, managing client expectations, and navigating difficult interactions, emerge as a persistent stressor across diverse regions (5, 12, 14, 15, 18, 19). Ethical dilemmas, such as euthanasia decisions, animal suffering, and conflicts between professional responsibilities and client preferences, present significant stressors, specific for the veterinary profession (15). Research has highlighted the emotional distress and moral challenges associated with ethical decision-making in veterinary practice (18, 20, 21). Administrative tasks, including paperwork, regulatory compliance, and financial management, also features prominently as stressors for veterinarians (12, 15). Investigations conducted in Belgium underscore the taxing nature of administrative formalities within the veterinary practice (14, 15). Financial worries, such as low compensation, debt burden, and income instability, further exacerbate stress levels among veterinarians. Research conducted in the US and other countries underscores the significant impact of financial worries on veterinarians` psychological well-being (18, 19). Moreover, gender-related issues, including perceived biases, disparities, and stereotypes, impact the experiences of male and female veterinarians. Studies elucidate gender differences in client interactions, career advancement, and work-life balance within the veterinary profession (22). For instance, a study examining factors influencing attrition from the veterinary profession in the UK found that female veterinarians were more predisposed to leave the field (17).

Research on veterinary students' view of work-related stressors is scarce. A study conducted in the UK observed differences in concerns about the work of a veterinarian in students compared to practitioners (23). Among students, the top five concerns included fears of making mistakes, achieving work-life balance, being responsible for clinical decisions, remembering information and grappling with self-confidence issues. Conversely, veterinary professionals highlighted work-like balance, compensation, and benefits, managing on-call duties, professional development opportunities, and regulation as key issues.

While these findings collectively illustrate the diverse array of challenges faced by veterinarians worldwide, there is a need to comprehensively examine the extent to which these stressors are perceived and the impact they have on specific mental health indicators. There is still limited research addressing the development and evaluation of targeted interventions aimed at equipping veterinary students with coping skills to navigate their future careers effectively.

This paper aims to contribute to the existing body of knowledge by exploring the anticipated and perceived stressors in the veterinary profession and their associations with mental health indicators. Additionally, it seeks to identify opportunities for the development of tailored interventions to support veterinary students and professionals in managing the unique stressors of their profession.

The following research questions are addressed:

1: To what extent do veterinary medicine students expect, and how do veterinarians actually experience, work-related stress factors within the veterinary profession?

1a: What are the differences in anticipated or experienced work-related stress factors between veterinary medicine students and practicing veterinarians?

1b: How do gender differences influence the perception of veterinary work-related stress factors?

2: What is the relationship between the work-related stress factors and indicators of mental health in veterinarians?

2 Materials and methods

2.1 Study design

Two cross-sectional online surveys targeting Austrian veterinary students and licensed Austrian veterinarians were conducted between November 16, 2022, and January 31, 2023. Recruitment and results on mental health indicators in comparison to the general Austrian population have been reported in detail in our companion studies (9, 10). In brief, all students enrolled in the diploma study of veterinary medicine in Austria ($N = 1,477$) were invited to participate in the survey by the Union of Students of the University of Veterinary Medicine Vienna and the registrar's office of the university. Furthermore, invitations to participate in the study were sent via email to all registered veterinarians in the Austrian Chamber of Veterinarians list who had provided valid email addresses ($N = 4,534$ veterinarians). The online surveys were conducted utilizing the LimeSurvey platform (LimeSurvey GmbH, Hamburg, Germany). Participation was entirely voluntary, and no incentives were offered to encourage participation.

2.2 Ethical considerations

This study adhered to the ethical principles outlined in the Declaration of Helsinki and received approval from the Ethics Committee of the University for Continuing Education Krems, Austria (Ethical number: EK GZ 25/2021–2024). All participants provided electronic informed consent to partake in the study before completing the questionnaires.

2.3 Measures

2.3.1 Professional characteristics

Veterinarians were queried regarding the animal species with which they engage professionally, encompassing ruminants, pigs, horses, poultry, pets, and exotic animals. Additionally, data regarding their employment status (employed or self-employed) and professional field (curative practice, university/research, consulting, abattoir, animal, and meat inspection, official veterinarian) were collected.

2.3.2 Work-related stressors

Practicing veterinarians were asked about their experienced stressors, whereas students were asked about their anticipated stress factors in their future occupation.

A series of 11 original items specifically focusing on potential sources of stress in the veterinary profession were provided. These included: communication with animal owners, communication with colleagues, communication with superiors, night/weekend shifts, working overtime, euthanasia, animal suffering, bureaucracy, professional overload, financial concerns, public pressure via social media.

Survey participants were asked to rate each item on a 5-point Likert scale (ranging from 0 to 4, with options from "not at all" to "very strongly") to express the extent to which each item contributed to the stress they encountered (vets) or anticipated to encounter in their future career (students). The option "not applicable" was also provided in the veterinarians' survey, which was coded "0" for further statistical analysis.

An open question was posed, inviting respondents to freely articulate additional estimated (students) or experienced (vets) stressors in the veterinary profession. For veterinarians, the question posed was: "Are there other aspects that you find stressful in your work as a veterinarian? If so, please describe them." Meanwhile, for veterinary students, the open-ended question took the form of: "Are there other aspects of working as a veterinarian that you consider stressful? If yes, please describe which ones?"

These items were developed collaboratively by a group of four individuals drawing from personal experiences in both academic study and practice, as well as through the identification of potential stressors documented in the veterinary literature. These questions were then subjected to pre-testing, where feedback from six veterinary students and seven practicing veterinarians were gathered. The feedback received from both veterinarians and students was largely positive, with most comments focusing on design and formatting issue, one participant observed that not all of the 11 listed stressors may apply universally to practicing veterinarians—for example, those working in the pharmaceutical industry do not have direct communication with animal owners. Consequently, the survey for veterinarians was amended after the pre-testing phase to include the option "not applicable" for such cases.

2.3.3 Well-being (Who-5)

The World Health Organization Well-Being Index (WHO-5) was used as a measure of well-being (24). The WHO-5 comprises five items that positively assess aspects of well-being on a six-point scale from 0 (none of the time) to 5 (all of the time), with higher scores indicating higher well-being. Cronbach's alpha was $\alpha = 0.85$ in the veterinarian sample and $\alpha = 0.84$ in the students` sample.

2.3.4 Perceived stress (PSS-4)

Perceived stress levels were assessed using the Perceived Stress Scale (PSS-4), which consists of four self-report items. Respondents used a five-point Likert scale, ranging from 0 (never) to 4 (very often), to rate their stress levels (25). Notably, items 2 and 3 were reverse-coded. Total PSS-4 scores ranged from 0 to 16, with higher scores indicating greater perceived stress. Internal consistency, measured by Cronbach's alpha, was $\alpha = 0.83$ in the veterinarian sample and $\alpha = 0.82$ in the students' sample.

2.3.5 Depressive symptoms (PHQ-9)

The Patient Health Questionnaire's depression module (PHQ-9) was used to assess depressive symptoms (26). The PHQ-9 comprises

nine self-rating items that evaluate symptoms of depression experienced over the past 2 weeks. Respondents rated these items on a four-point scale, ranging from 0 (not at all) to 3 (nearly every day), resulting in a total score ranging from 0 to 27 (27). The internal consistency (Cronbach's alpha) was $\alpha = 0.86$ in veterinarians and $\alpha = 0.84$ in the students' sample.

2.3.6 Anxiety (GAD-7)

Anxiety symptoms were assessed using the Generalized Anxiety Disorder 7 scale (GAD-7), which includes seven self-rating items (28). Respondents reported symptoms of generalized anxiety over the past 2 weeks on a four-point scale from 0 (not at all) to 3 (nearly every day). Total scores ranged from 0 to 21, with higher scores indicating more severe anxiety symptoms (29). The internal consistency, Cronbach's alpha, was $\alpha = 0.86$ in the veterinarians' and $\alpha = 0.88$ in the students' sample.

2.3.7 Insomnia (ISI-2)

The assessment of sleep quality utilized the two-item version of the Insomnia Severity Index (ISI) (30). The ISI-2 self-rating items gauged an individual's satisfaction or dissatisfaction with their current sleep patterns and the extent to which these patterns interfered with daily functioning. Respondents used a five-point Likert scale, ranging from 0 to 4, for rating these items. The total ISI-2 score could range from 0 to 8, with higher scores suggesting stronger impairment in sleep quality (31). Cronbach's alpha was $\alpha = 0.71$ in the veterinarian sample and $\alpha = 0.43$ in the students' sample.

2.4 Statistical analyses

All statistical tests were performed in SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, United States).

To evaluate potential differences in the experienced/expected work-related stressors regarding area (11 assessed stressors), group (students, veterinarians), and gender (female, male), a repeated measures analysis of variance (RM-ANOVA) was conducted. In this RM-ANOVA the estimated (students) or the experienced (veterinarians) work-related stress was the dependent variable. There was one within-subject factor, i.e., "stressor" (11 levels: communication with animal owners, communication with colleagues, communication with superiors, night/weekend shifts, working overtime, euthanasia, animal suffering, bureaucracy, professional overload, financial concerns, public pressure via social media). There were two between-subject factors, the first was "group" (two levels: veterinary students, veterinarians) and the second was "gender" (two levels: men, women). The Greenhouse–Geisser corrected values are reported. Significant main and interaction effects were followed up by Bonferroni-corrected simple effects two-tailed tests.

To reveal potential associations of occupational factors with work-related stressors *t*-tests for independent samples were conducted. Occupational factors including employment status (self-employed vs. employed), professional field (curative practice vs. other fields), and animal species (working with specific species vs. not) were dichotomized for the statistical analysis. All tests were two-tailed, and the significance value was set to $p < 0.0045$ ($p < 0.05/11$ *t*-tests per occupational factor).

To analyze potential associations of a given work-related stressor with the surveyed mental health indicators (WHO-5, PSS-4, PHQ-9, GAD-7, ISI-2) in veterinarians, Pearson correlation coefficients (r) were calculated. Correlation analyses were conducted two-tailed and Bonferroni-corrected results were reported with $p < 0.00091$ ($p < 0.05/55$ bivariate correlation analyses). For completeness, data from students were also examined. In this analysis, current mental health indicators were correlated with the anticipation of future stressors in the veterinary profession.

2.5 Qualitative analyses

Responses to the open-ended questions underwent a thorough qualitative content analysis process (32). The initial step involved reading all the data to establish familiarity with the material and obtain a comprehensive overview of the responses. Each response was then meticulously examined, word by word, through multiple iterations. During this phase, categories for the open-ended questions were developed through an inductive approach, and comprehensive definitions for each category, along with coding guidelines and illustrative quotations, were documented in a codebook. Subsequently, subcategories sharing similar content were amalgamated into broader, more conceptually focused main categories. In the following phase, the dataset was systematically coded using the ATLAS.ti software (33). Given that respondents had the freedom to address multiple aspects within each question, assigning more than one category to a single response was a possibility. Once the entire dataset had been coded, all quotations linked to specific categories underwent a reevaluation to rectify any coding inaccuracies. Any identified coding errors were rectified, and, if necessary, category definitions and coding guidelines were refined.

3 Results

3.1 Sample description

A total of 430 students (29.1% of the total population of Austrian veterinary medicine students) and 440 veterinarians (9.7% of the total population of Austrian veterinarians) participated in the study. The student sample comprised 85.8% women, 13.5% men and 0.7% gender-diverse persons. Participants were on average 23.14 ± 3.69 years old. The veterinarian sample comprised 72.0% women and 28.0% men with an average age of 44.53 ± 11.25 years. Due to the low number of gender-diverse individuals ($n = 3$ in the students' sample, $n = 0$ in the veterinarian sample), they were excluded from further statistical analyses.

3.2 Extent of expected/perceived stress factors in the veterinary profession

Results of the RM-ANOVA revealed a significant main effect of group ($p < 0.001$), gender ($p < 0.001$) and stressor ($p < 0.001$). Also, the two-way interaction between group and stressor ($p < 0.001$) as well as gender and stressor ($p < 0.001$) reached significance, whereas neither the two-way interaction between group and gender ($p = 0.662$), nor the three-way interaction between group, gender, and stressor ($p = 0.053$) were significant.

The main effect of group revealed that students perceived the work-related stressors to be more burdensome (M = 1.95, SEM = 0.047) than veterinarians (M = 1.52, SEM = 0.036). Women indicated work-related stressors to be more burdensome (M = 1.90, SEM = 0.026) than men (M = 1.57, SEM = 0.053). The main effect of stressor is illustrated in detail in Supplementary Figure S1. In brief, animal suffering, bureaucracy, communication with animal owners, working overtime and night/weekend shifts were rated as the most burdensome stressors, not differing from each other. Financial concerns were at an intermediate position, followed by professional overload, euthanasia, and public pressure via social media. Communication with superiors and colleagues were rated to be the least burdensome.

The interaction of group and stressors (Figure 1) revealed that students estimated almost all the stressors to be higher than actually experienced by veterinarians, with the exception of bureaucracy (all pair-wise Bonferroni corrected post-hoc tests $p < 0.05$).

Statistical significant differences ($^{*}p < 0.05$ and $^{**}p < 0.01$; respectively) between the perceived (students) and experienced (veterinarians) burden within each stressor.

Significant differences in stressors within the veterinarian sample are depicted in more detail in Figure 2. Bureaucracy was experienced as the most burdensome stressor, followed by animal suffering and communication with animal owners. Also, night/weekend shifts and working overtime ranked among the top 5 stressors. Financial concerns were intermediate, not differing significantly from stressors due to public pressure via social media, euthanasia, and professional overload. Communication with colleagues and superiors were rated to be the least burdensome.

Students expected animal suffering, working overtime, night/weekend shifts, communication with animal owners and financial concerns as most burdensome (Supplementary Figure S2). Bureaucratic burden was intermediate, not differing significantly from stressors due to euthanasia and public pressure via social media. The lowest burden was expected due to communication with superiors and colleagues.

The analysis of the interaction between gender and stressor (Figure 3) shows that women indicated bureaucracy as less burdensome than men, whereas the opposite was noticed for all other work-related stressors (all pair-wise Bonferroni corrected post-hoc tests $p < 0.05$).

Bonferroni-corrected comparisons within gender are shown in more detail in Supplementary Figures S3, S4. In women, animal suffering was the top stressor, followed by communication with animal owners, working overtime and night/weekend shifts (Supplementary Figure S3). Bureaucracy, financial concerns, professional overload and euthanasia were intermediate. Communication with colleagues was rated to be the least burdensome.

Significant differences in stressors within men are depicted in more detail in Supplementary Figure S4. Bureaucracy was the main stressors, followed by night/weekend shift, working overtime, communication with animal owners and animal suffering. Euthanasia, communication with superiors and colleagues were rated as the least burdensome.

Results on the associations of occupational factors with work-related stressors are summarized in Supplementary Tables S1–S8. In brief, self-employed veterinarians experience more bureaucratic burdens but fewer issues with superiors. Veterinarians in curative

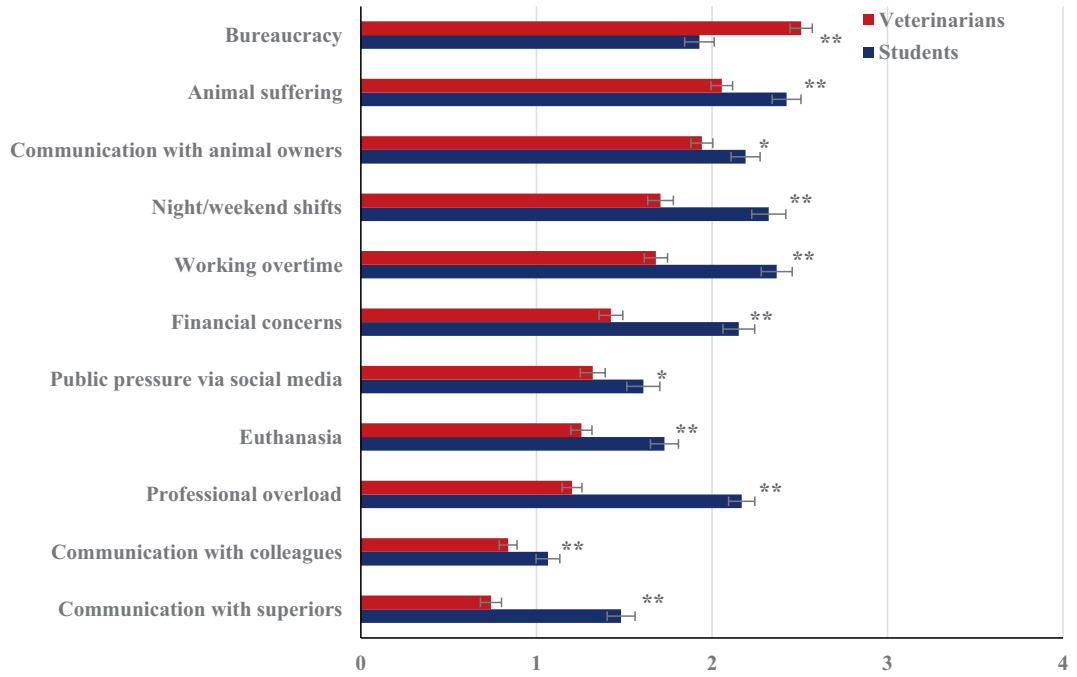

FIGURE 1
Estimated veterinary work-related stressors in veterinary students versus experienced work-related stressors in veterinarians rated on a 5-point scale from 0 "not at all or not applicable" to 4 "very strongly". The stressors are listed in descending order, as reported by the veterinarians.

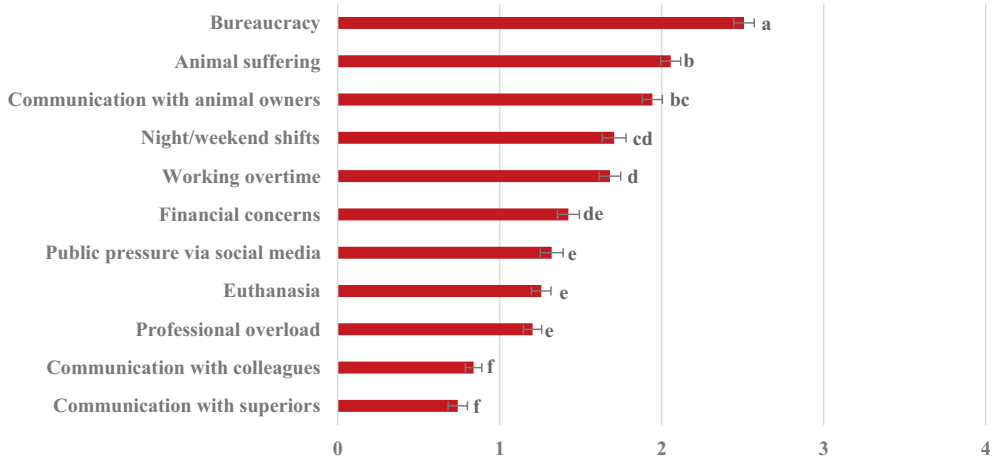

FIGURE 2
Experienced veterinary work-related stressors in veterinarians rated on a 5-point scale from 0 "not at all or not applicable" to 4 "very strongly". Different letters (a, b, c, d, e, f) indicate statistically significant differences between stressors. Stressors with different letters are significantly different from each other ($p < 0.05$ after Bonferroni-correction).

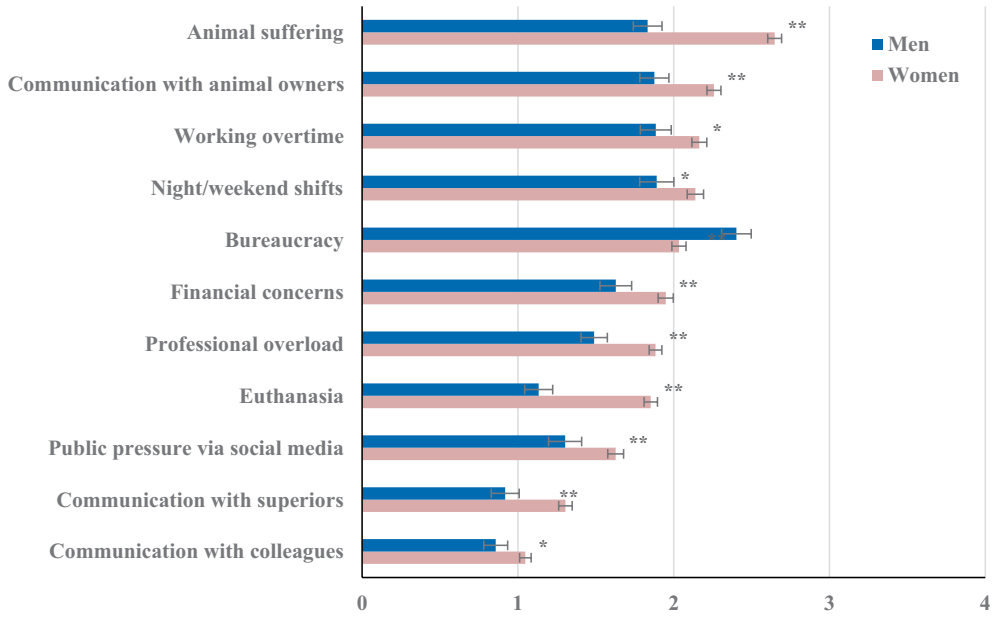

FIGURE 3
Estimated/experienced veterinary work-related stressors in female versus male veterinary students and veterinarians. The 11 pre-defined work-related stressors were rated on a 5-point scale from 0 "not at all or not applicable" to 4 "very strongly". The stressors are listed in descending order of the females. **The difference between men and women within each stressor is significant at the 0.01 level. *The difference between men and women within each stressor is significant at the 0.05 level.

practice stated to be more heavily burdened by night and weekend shifts compared to those not in curative practice. Veterinarians working with livestock stated to encounter more bureaucratic burdens (especially those working with ruminants and pigs) but to have fewer financial concerns (i.e., veterinarians working with ruminants and poultry) than those not working with these animals. Small animal practitioners seem to be particularly confronted with communication with pet owners, professional overload, financial worries, and public pressure via social media.

3.3 Qualitative results

3.3.1 Results: practicing vets

Within the $N = 440$ veterinarians who took part in the study, 363 answered the open-ended question: "Are there other aspects that you find stressful in your work as a veterinarian? If so, please describe them." Of these, $n = 7$ participants did not indicate any other stresses. Therefore, responses of 356 veterinarians were analyzed. Qualitative content analysis resulted in 16 main categories

TABLE 1 Main and subcategories that emerged from the content analysis of the open-ended question: "Are there other aspects that you find stressful in your work as a veterinarian? If so, please describe them."

Main and subcategories	*N*	%
Workplace-related stressors	93	21.1%
High workload	48	10.9%
Permanent availability	19	4.3%
High mobility	7	1.6%
Self-employment	5	1.1%
Training	4	0.9%
Heavy physical work	3	0.7%
Gender relations	2	0.5%
Career advancement	1	0.2%
Hierarchy	1	0.2%
Noise in the workplace	1	0.2%
High responsibility	1	0.2%
Technicisation of medicine	1	0.2%
Expectations of animal owners	44	10.0%
Financial aspects	40	9.1%
Settlements with animal owners	20	4.5%
Underpayment	13	3.0%
Tax/duties	4	0.9%
Cost/inflation	3	0.7%
Colleagues	28	6.4%
Expectations	12	2.7%
Uncollegiality	9	2.0%
Issues with superiors	5	1.1%
Competitive pressure	2	0.5%
Mental stressors	20	4.5%
Mental stress	12	2.7%
Self-doubt	4	0.9%
Bullying	2	0.5%
Suicide among colleagues	1	0.2%
Lack of psychological knowledge	1	0.2%
Ethical aspects	16	3.6%
Animal suffering/welfare	10	2.3%
Animal as a substitute	4	0.9%
Euthanasia	2	0.5%
Work-life-Balance	15	3.4%
Bureaucracy	13	3.0%
Professional associations	12	2.7%
Austrian Veterinary Chamber	10	2.3%
Animal health services	2	0.5%
Online platforms	10	2.3%
Negative reviews	7	1.6%
Online advisors	3	0.7%
Lack of appreciation	9	2.0%
Leading a team	5	1.1%
Shortage of skilled staff	5	1.1%
Other	4	0.9%
Politics	2	0.5%
Shortage of medication	2	0.5%

Percentages relate to the whole study sample of veterinarians who took part in the survey ($n = 440$) and not to the participants who answered the open-ended question ($n = 356$).

and 32 subcategories. All main and subcategories are shown in Table 1.

3.3.1.1 Workplace-related stressors

The main stress factor for the veterinarians was "Workplace-related stressors," which was mentioned by 21.1% ($n = 93$) veterinarians. This main category comprised 12 subcategories. The largest subcategory with $n = 48$ was "high workload," as described by respondent (R) R 125: "*I worked as a vet after my studies, in 24-h clinics with night shift as well. I would not wish that time on anyone. Not knowing whether you have a holiday off or must work is stressful. Not knowing whether you can be with your family at Christmas or whether you have a 12 or even 24-h shift is very stressful. Regular working hours are rare.*" The second subcategory with $n = 19$ concerns "permanent availability" as a veterinarian. Another subcategory was "high mobility" at work mentioned by $n = 7$ vets. "Self-employment" in the veterinary profession is mentioned by $n = 5$ as a further stress factor. "Training" (0.9%, $n = 4$) as a burden was mentioned by people who either saw a discrepancy between teaching at the university and veterinary practice (R. 284) or did not have the financial means for training (R. 364). Heavy physical work mentioned by $N = 3$ was also perceived as a stress. "Gender relations" are mentioned as a pressure by $n = 2$ participants: "*But men are more likely to be protected by senior bosses than women! It's a secondary burden that you have to be twice as good as woman, but even if you are, you are severely disadvantaged and undervalued because of your uterus and the possibility of becoming pregnant, even though you have the greatest potential and the highest education of all*!" (R. 173). "Career advancement" ($n = 1$), "Hierarchy" ($n = 1$), "Noise in the workplace" ($n = 1$), "High responsibility" ($n = 1$) and "Technicisation of medicine" ($n = 1$) were further subcategories.

3.3.1.2 Expectations of animal owners

This main category subsumed the animal owners' general expectations of veterinarians. In their responses, 10.0% ($n = 44$) described the attitude of the animal owners and the pressure or inadequacies to which they are exposed, for example R. 388: "*The implicitness with which it is expected that, as a vet, you do not refuse to help at any time, as you are unfortunately too morally obligated*". In this context, reference is also made to the expectation of animal owners who want to relinquish responsibility but do not really co-operate with veterinarians, such as R. 244: "*That patient owners want us to relieve them of all responsibility on the one hand, but at the same time have no trust.*"

3.3.1.3 Financial aspects

The third main category is "Financial aspects" (9.1%, $n = 40$), comprising of four subcategories. The majority of statements ($n = 20$) fell within the subcategory "settlements with animal owners" such as "*The conversation about costs and that patient owners keep blaming us vets*" (R. 244). The second subcategory describes "underpayment" ($n = 13$) as a veterinarian: "*Although I am always available and work as much as I can, there is never any money left over, saving is impossible*" (R. 126). Two further subcategories were "tax/duties" ($n = 4$) and "cost/inflation" ($n = 3$).

3.3.1.4 Colleagues

The main category "Colleagues" with 6.4% ($n = 28$) is composed of answers dealing with the expectations of colleagues and lack of solidarity among colleagues that can be subsumed in four categories. The first subcategory with ($n = 12$) refers to the general "expectations" among colleagues at the workplace, the attitude of older colleagues towards younger colleagues or the generational conflict as described by R. 196: "*Generational conflict - older colleagues always generalize that younger colleagues do not want to work. I get this resentment too, even though I work 40 h a week and often do overtime*." The second subcategory ($n = 9$) comprised those responses that indicated "uncollegiality" in the veterinarians' working environment. The subcategory "Issues with superiors" with 1.1% ($n = 5$) consisted of responses that referred to conflicts with managers. The last subcategory is "competitive pressure" among colleagues with $n = 2$.

3.3.1.5 Mental stressors

The main category "Mental stressors," with $n = 20$ (4.5%) responses, refers to psychological and emotional pressure from working as a veterinarian and was summarized into five subcategories. The first subcategory, with $n = 12$, is "mental stress" outside of working hours, such as R. 169 emphasized: "*not being able to switch off in your free time … the feeling of being "alone" …*" In the "self-doubt" subcategory ($n = 4$), participants stated that they felt they were not good enough for the job and had doubts about their own professional performance: "*Self-doubt that the animal would have been treated better elsewhere. Feelings of guilt that the animal has now ended up with me. Questioning after the working day whether I have really done everything possible. Fear of having forgotten something*" (R. 184). The three other subcategories were "Bullying" ($n = 2$), "Suicide among colleagues" ($n = 1$) and "Lack of psychological knowledge" ($n = 1$).

3.3.1.6 Ethical aspects

A total of $n = 16$ (6.3%) respondents reported further stressors related to ethical aspects. This main category comprised three subcategories. The subcategory of "Animal suffering/welfare" (2.3%, $n = 10$) as a stress factor is made up of responses that are confronted with animal distress in the course of their veterinary work, which could be caused by neglect on the part of animal owners. The subcategory "animal as a substitute" (0.9%, $n = 4$) was an indication of the role of the animal as a substitute for a child or partner that was not fulfilled. The subcategory of "euthanasia" was emphasized by 0.5% ($n = 2$) of participants as a stress factor.

3.3.1.7 Work-life-balance

The next main category was the "Work-life-balance" (3.4%, $n = 15$). For example, R. 282 wrote: "*With family routines, possibly planning holidays, or the feeling of not having enough time for partner and children*."

3.3.1.8 Bureaucracy

The main category of "Bureaucracy" was mentioned by 3.0% ($n = 13$) respondents. For example, respondent 124 wrote that there was little time left for work because of bureaucratic regulations: "*Time for actual veterinary work is becoming increasingly scarce due to unnecessary and unpaid bureaucratic tasks that have nothing to do with veterinary medicine*."

3.3.1.9 Professional associations

Another main category concerns the "Professional associations" with 2.7% ($n = 12$) responses. The first subcategory is the "Austrian Veterinary Chamber" with $n = 10$. Respondent 34 expressed his dissatisfaction as follows: "*Lack of support from the Austrian Veterinary Chamber with regard to legal certainty in the practice of the profession*." The next subcategory was "animal health services" ($n = 2$), referring to governmental institutions responsible for monitoring and promoting animal health and implementing disease control measures.

3.3.1.10 Online platforms

The main category "Online platforms" (2.3%, $n = 10$) refers to anonymous ratings and reviews online such as Google and also to guides on the internet. This main category comprised of two subcategories: "Negative reviews" with $n = 7$ and "online advisors" with $n = 3$.

3.3.1.11 Further main categories

The main category "Lack of appreciation" with 2.0% ($n = 9$) referred to a disregard and lack of acceptance of the veterinarians' contributions to society and to animal owners. The main category of "Leading a team" (1.1%, $n = 5$) refers to aspects of stress associated with leadership tasks. Another main category was the "Shortage of skilled staff" with 1.1% ($n = 5$). All responses that could not be assigned to the main or subcategories were subsumed in the main category "Other" (0.9%, $n = 4$). The main category of "Politics" (0.5%, $n = 2$) is made up of very short answers on general politics as a stress factor. The main category "Shortage of medication" is also made up of 0.5% ($n = 2$) responses.

3.3.2 Results: veterinary students

A total of $N = 430$ veterinary students participated in the study. $N = 122$ of the participants answered the open-ended question: "Are there other aspects of your work as a veterinarian that you consider stressful? If yes, please describe which ones." Of these, $n = 3$ participants did not report any other stressors and 3 participants will not be practicing veterinary medicine after graduation. The responses of 116 participants were analyzed and resulted in 10 main categories and 30 subcategories (Table 2). The results of the main and subcategories of content analysis are described below.

3.3.2.1 Workplace-related stressors

The most frequently mentioned stress factor for veterinary students was "workplace-related stressors," described by $n = 51$ (11.9%) of respondents. The largest subcategory with $n = 19$ was "working conditions" and included responses such as general workload, irregular shifts or the general "*amount of work due to a shortage of veterinarians*" (R. 184). The second subcategory, with $n = 11$, concerns

TABLE 2 Main and subcategories that emerged from the content analysis of the students' open-ended question: "Are there other aspects of working as a veterinarian that you consider stressful? If yes, please describe which ones?"

Main and subcategories	*n*	%
Workplace-related stressors	51	11.9%
Working conditions	19	4.4%
Stress and pressure to perform	11	2.6%
Responsibility	9	2.1%
Gender relations	7	1.6%
Competitive pressure	4	0.9%
Continuing education	3	0.7%
Education-career transition	2	0.5%
Career choice	1	0.2%
Work-life-balance	50	11.6%
Compatibility of family and career	27	6.3%
Work-life preference	23	5.3%
Mental stressors	32	7.4%
Self-doubt	10	2.3%
Anxiety	10	2.3%
Mental stress	5	1.2%
Uncertainty	4	0.9%
Burnout	1	0.2%
Well-being	1	0.2%
Boringness	1	0.2%
Financial aspects	29	6.7%
Underpayment	15	3.5%
Financial issues with animal owner	9	2.1%
Veterinary association fees	2	0.5%
Lack of compensation	1	0.2%
Inflation	1	0.2%
Insurance costs	1	0.2%
Communication with animal owners	10	2.3%
Ethical aspects	6	1.4%
Animal suffering	2	0.5%
Ethical considerations	2	0.5%
Animal as a substitute	1	0.2%
Compassion for animals	1	0.2%
Lack of appreciation	5	1.2%
Public pressure	4	0.9%
Bureaucracy	4	0.9%
Official veterinarians	2	0.5%
Legislative problems	1	0.2%
Bureaucratic hurdles	1	0.2%
Other	3	0.7%

Percentages relate to the whole study sample of veterinary students who took part in the survey ($n = 430$) and not to the participants who answered the open-ended question ($n = 116$).

"stress and pressure to perform" directly related to working conditions. The third subcategory is made up of responses (with $n = 9$) that describe "responsibility" and was specifically taking care of the life and welfare of animals. "Gender relations" at work was mentioned as a pressure by $n = 7$ participants: "*Gaining the respect of customers as a woman*" (R. 65). "Competitive pressure" with $n = 4$ answers showed a high level of agreement both among students and in order to get a suitable training place. R. 219 addressed it as follows: "*Increasing competitive pressure among students during their studies and the associated decrease in willingness to help each other.*" The subcategory "continuing education" ($n = 3$) refers to those responses that considered compulsory continuing education during their employment to be a burden. The category "education-career transition" ($n = 2$) indicated a stress factor related to starting work after leaving university. Other subcategories were "education-career transition" ($n = 2$), and "career choice" with $n = 1$.

3.3.2.2 Work-life-balance

The main category of "work-life-balance" ($n = 50$, 11.6%) included stressors that result from an interaction between the person and the environment and influence the experience of balance. The first subcategory was "compatibility of family and career" ($n = 27$) and signaled the difficulty of starting a family as a veterinarian. For example, R. 135 described "*in livestock farming, the vet has to prioritize his profession over his private life.*" The second subcategory, "work-life preference" mentioned by $n = 23$ participants, indicated either a lack of balance between work and private life or concern about the possibility of achieving a balance at all. Another aspect related to the shortage of leisure time for social activities.

3.3.2.3 Mental stressors

The main category "Mental stressors," with $n = 32$ (7.4%) responses, related to the psychological and emotional aspects of working as a veterinarian. In the first subcategory "self-doubt" ($n = 10$), students stated that they feared that they would not be well qualified for the practical side of the profession after graduation: "*When I graduate as a vet, I've already heard that I'll get my own patients from day one, even though I have no idea. This really gets me down and I'm thinking of changing to a profession where you have less responsibility, I'm afraid of failing*" (R. 239). The second subcategory labeled "anxiety" ($n = 10$) refers to worries about making professional mistakes due to time pressure and stress. The third subcategory, "mental stress" ($n = 5$), referred to psychological stresses that arose during the study and caused general concern, such as "*depression and suicide rates among veterinarians*" (R. 218). The subcategory "uncertainty" ($n = 4$) referred to responses that perceived lack of knowledge and helplessness in practice as a stressor. The other three subcategories were "burnout" ($n = 1$), "well-being" ($n = 1$) and "boringness" ($n = 1$).

3.3.2.4 Financial aspects

The main category "financial aspects," mentioned by $n = 29$ (6.7%) participants, consisted of different aspects directly related to financial concerns. The first subcategory "underpayment," with $n = 15$ responses, indicated the link between high workload and low pay in the profession. The second subcategory, "Financial issues with animal owners" ($n = 9$), highlights concerns about the financial aspects of animal treatment that owners do not provide: "*… having to talk to pet owners about money and sometimes not being able to do proper treatments because they are too expensive …*" (R. 105). Other subcategories are "veterinary association fees" ($n = 2$), "lack of compensation" ($n = 1$), "inflation" ($n = 1$) and "insurance costs" ($n = 1$).

3.3.2.5 Communication with animal owners

The main category "communication with animal owners," mentioned by $n = 10$ (2.3%) respondents, indicates stress factors in the interaction between animal owners and veterinarians, as there are different expectations. R. 155 expressed it as follows: "*Reconciling the welfare of the animal with the wishes of the owner.*"

3.3.2.6 Ethical aspects

The main category "Ethical aspects" with $n = 6$ (1.4%) was based on the following subcategories: "animal suffering" ($n = 2$), "ethical considerations" ($n = 2$), "compassion for animals" ($n = 1$) and "animal as a substitute" ($n = 1$) to replace a missing partner or child.

3.3.2.7 Lack of appreciation

The main category "lack of appreciation" ($n = 5$) referred to stress factors related to the general acceptance of veterinary services in society, i.e., a veterinarian is not recognized as much as a human doctor (R. 173 and 203).

3.3.2.8 Further main categories

The main category "public pressure" ($n = 4$, 0.9%) consisted of responses that identified the public's expectations of veterinarians as a stress factor. The main category "bureaucracy" ($n = 4$, 0.9%) was composed of three subcategories, which were either administrative worries with "official veterinarians" ($n = 2$) or "legislative problems" ($n = 1$) or "bureaucratic hurdles" ($n = 1$) as a future burden in the profession. All responses from students that could not be assigned to the main or subcategories were included in the category "Other" ($n = 3$, 0.7%).

3.4 Associations between perceived occupational stress factors in veterinarians and indicators of mental health

Table 3 illustrates correlations observed between mental health indicators in veterinarians and the extent of experienced stressors among the 11 pre-defined occupational stressors.

Strongest associations of perceived stress and mental health indicators were observed for financial concerns, with Pearson correlation coefficients ranging from $r = 0.36$ to $r = 0.47$. Also, the perceived stress through communication with animal owners showed a moderate correlation with all investigated mental health parameters (r between 0.30 and 0.39). The extent to which night/weekend shifts and working overtime were perceived as stressful were also moderately associated with symptoms of depression, anxiety, well-being and stress (r between 0.31 and 0.37). The stressor with the weakest association with mental health indicator was bureaucracy (r between 0.14 and 0.21).

Associations of expected stress and actual mental health indicators in students are summarized in Supplementary Table S9, revealing only weak associations (r between 0.03 and 0.29). Interpreting these results must be approached with caution, as it's intricate to establish a direct relationship between current emotional states and future stressors.

4 Discussion

One major finding of the present study elucidates that aspiring veterinarians exhibit a notable awareness of the substantial stress associated with their desired profession. Remarkably, their perceptions consistently exceed the experienced stress levels in all domains, except for administrative stressors. This empirical evidence substantiates that there is no need to further highlight the already acknowledged occupational stress. Instead, it underscores the paramount need for targeted interventions aimed at imparting requisite coping skills to students. Such interventions are indispensable for equipping these future professionals with the proficiency to navigate their forthcoming careers adeptly, consequently mitigating the risk of psychological overload and premature career attrition. These results not only contribute to the scholarly understanding of veterinary education but also hold practical implications for the development of tailored interventions and support mechanisms in this professional domain.

A further main finding is that Austrian veterinarians identified bureaucracy as the most onerous factor from a predefined list of 11

TABLE 3 Pearson correlation analyses investigating associations of the experienced burden of work-related stressors and indicators of mental health in Austrian veterinarians ($N = 440$).

Stressor	Depression (PHQ-9)	Anxiety (GAD-7)	Insomnia (ISI-2)	Well-being (WHO-5)	Stress (PSS-4)
Communication with animal owners	0.389*	0.391*	0.301*	−0.319*	0.351*
Communication with colleagues	0.335*	0.347*	0.206*	−0.242*	0.316*
Communication with superiors	0.320*	0.297*	0.213*	−0.242*	0.283*
Night/weekend shifts	0.369*	0.310*	0.243*	−0.339*	0.314*
Working overtime	0.373*	0.370*	0.277*	−0.374*	0.346*
Euthanasia	0.335*	0.326*	0.277*	−0.200*	0.261*
Animal suffering	0.316*	0.276*	0.257*	−0.217*	0.267*
Bureaucracy	0.164*	0.141	0.206*	−0.176*	0.212*
Professional overload	0.385*	0.394*	0.258*	−0.291*	0.322*
Financial concerns	0.461*	0.473*	0.361*	−0.375*	0.426*
Public pressure via social media	0.314*	0.327*	0.258*	−0.214*	0.325*

*The correlation is significant after correcting for multiple testing ($p < 0.05/55$ correlation analyses). Work-related stressors were rated on a 5-point Likert scale ranging from 0 "not at all/not applicable" to 4 "very strongly".

potential stressors. Additionally, studies conducted in Belgium and the UK (12, 15) revealed that administrative formalities were consistently rated as highly stressful within the realm of veterinary practice. However, these prior investigations did not establish a direct link between this administrative burden and its impact on mental health indicators. In our own study, while bureaucracy similarly emerged as the predominant stressor within the veterinary profession, we found that its correlations with perceived stress levels and insomnia were small ($r = 0.21$), with negligible associations observed in relation to other health indicators ($r < 0.20$). This suggests that other factors, not directly related to administrative burdens, may play a more significant role in contributing to the overall stress and well-being of veterinary professionals. Moreover, it's worth noting that dealing with bureaucracy is not a skill veterinarians are explicitly trained for or aim to do in their daily practice. It is not the primary focus of their veterinary training. The bureaucratic tasks keep veterinarians from focusing on what they were trained for, adding to their stress levels. This may explain why bureaucracy is not highlighted as a significant stressor by students, as they enter the profession unprepared for the administrative burden of legal formalities, managing orders, taxes, and other bureaucratic tasks.

Contrary to administrative duties, financial worries did not rank among the top job-related concerns of Austrian veterinarians; nevertheless, they exhibited the strongest negative association with mental health. These findings align with research conducted in the Austrian general population, which indicated the highest prevalence of mental illness symptoms within the low-income group (34). Notably, previous studies in the United States have highlighted financial concerns as significant occupational stressors linked to psychological distress in veterinarians (19, 35). However, direct comparisons with these studies are complex due to variations in the educational systems and financial burdens encountered. It is pertinent to recognize that in Austria, most degrees, including veterinary medicine, are publicly funded, with students generally not incurring tuition fees for their education. The results of the current study underscore the significance of low compensation within the veterinary profession as the most substantial factor associated with poor mental health among veterinarians. Given the substantial stress levels and the tangible influence of financial pressures, seeking guidance from certified financial planners to establish sustainable strategies for managing living expenses within income constraints could prove to be a beneficial avenue for addressing this critical issue already during education. In addition to addressing individual financial concerns, it's crucial to acknowledge the systemic issues within the veterinary profession that contribute to financial stress. For instance, the fact that veterinarians are often paid by other veterinarians may lead to internal conflicts over fair compensation and recognition of financial burdens. Moreover, the implementation of fee regulations, as seen in Germany, could prevent price undercutting and provide veterinarians with more stability in their earnings. Furthermore, systemic factors such as economic conditions, political decisions, and market forces, particularly in agricultural settings, significantly impact how much clients are willing to pay for veterinary services. By considering these systemic challenges and advocating for structural changes, we can address the root causes of financial stress among veterinarians, going beyond individual financial management strategies.

Results on high perceived burden through conversation with animal owners as well as the association of this perceived burden with mental health indicators is in line with previous studies conducted in the US, UK, Belgium, and Germany ranking client relations among the most stressful factors identified by veterinarians (5, 12, 15, 19, 35). More specifically, dealing with clients was stated to be burdensome due to client complaints, dealing with client grief, client expectations, lack of respect, ungratefulness, later/unpaid invoices, and phone harassment during practice. Indeed, also answers to the open-ended question on further perceived job-related worries in the study at hand revealed several stressors related to client expectations, such as being accessible around the clock or worries related to treatment costs. The perception of clients who view animals as "objects" or as "substitutes for human relationships (partners/children)" is also regarded as burdensome. In Austria, veterinarians have historically not received specialized training for interacting with people. It's only in recent years that veterinary students have been introduced to a course on "client conversation" as part of their curriculum. It is important to acknowledge that individuals who choose to study veterinary medicine possess specific cognitive and personality traits (7). Subconsciously, the decision to pursue a veterinary career may be influenced by a preference for working with animals rather than people, which could consequently impact their perception of client interactions as burdensome. Moreover, veterinary students are often under high academic pressure, facing a demanding curriculum and intense competition, which may hinder the development of their social and communication skills (7).

Animal suffering ranked among the most stressful factors reported in the current study. A unique challenge in veterinary practice is the dependency of the animals' well-being on the owners' decisions and financial situation. The animal owner might for instance decide against veterinary advice in terms of treatment (e.g., if they cannot afford the treatment costs, or refuse euthanasia for a pet "acting as a surrogate child" due to emotional attachment despite severe health issues) but also in terms of other aspects such as housing or breeding. Although in Europe there are official regulations regarding how the different animal species should be housed, there are many animal owners who do not stick to the rules, are not aware, or do not care how and if their animal is kept up to its natural needs. Another veterinary-specific issue pertains to breeding practices aimed at achieving certain aesthetic standards, often at the expense of animal welfare and health. The human ideas of an "ideal" individual within a breed has led to the breeding of various races within dogs, cats, and cattle, with a predisposition to numerous health issues and syndromes. Unfortunately, many animal owners fail to grasp the physical discomfort experienced by their animals due to genetic factors. This lack of awareness often results in the neglected veterinary advice and the perpetuation of breeding practices that prioritize aesthetics over the well-being of the animals involved (21). All these circumstances put ethical pressure on the vet, often recommendations of veterinarians to client owners are not followed, making the situation for the animal more miserable.

A further stressor, mostly unique for veterinarians, is performing euthanasia. However, neither in our study, nor in previous studies did euthanasia rank among the top 5 stressors reported by veterinarians (15, 18). As animal suffering, or the grief of clients or the staff due to animal illness or euthanasia are ranked more frequently as stressors, findings could suggest that not the death of the animals itself is putting most stress on veterinarians, but rather the intense emotional distress experienced by the humans involved. Further open questions revealed that ethical pressure, when the owner has no money or bad compliance to treat the animal, is rather a stressor than euthanasia *per se*.

Furthermore, trait perfectionism, i.e., the tendency to have very high and rigid standards for the self and/or others, as an individual difference, increases vulnerability to experiencing heightened distress when confronted with morally challenging situations in veterinary practice (20). As morally significant stressors on their own tend to elicit only mild distress, the individual's personality traits might have a more significant predictive role in job-related stress than the work environment itself (36).

Overall, our findings point out that the aspects of social interaction and ethical concerns are detrimental risk factors. The situation is further compounded by the observation that as working hours increase, the capacity for empathic and compassionate interactions, especially with grieving client owners, diminishes (37).

In line with previous studies, we observed a high perceived burden through night/weekend shifts and working overtime. Studies conducted in Australia, Belgium, Finland, the UK, Germany and New Zealand observed that the frequent overtime, on-call duties and weekend service represented one of the main stressors in the veterinary profession (5, 12–16). The top number one source of stress given by practice owners, practice associates, and relief vets was the demands of practice, e.g., long working hours, work overload (35) and poor work-life balance were reported to be the top reason to leave the veterinary profession (5). High working hours are at the expense of leisure time activities, such as engaging in physical activity and social relationships. Therefore, results of the present study are in line with our previous results, showing increased mental health burden in veterinarians who are physically inactive outside their professional activities (10). As supported by the correlation analyses, a poor work-life balance can lead to diminished mental health. Free text answers to the open-ended question on other work-related perceived stress factors revealed that a poor work-life balance was a significant stressor for veterinarians. They reported a lack of compatibility between their professional and personal life, particularly when it comes to fulfilling family responsibilities alongside work commitments. Overall, the analysis of free-text responses of students regarding aspects expected to be stressful in their future careers as veterinarians indicates that students primarily fear poor work-life balance and difficulties in reconciling their profession with family life. These results, coupled with the generally higher perceived work-related stress levels by students compared to the veterinarians, may suggest that the demanding workload experienced by Austrian veterinarians could be a major contributing factor to premature attrition from the profession. It's worth noting that the sample of veterinarians primarily includes those who have chosen to remain in the profession, rather than those who have already pursued different career paths due to the substantial stress they experienced. Therefore, it can be concluded that lower job-related demands enabling veterinarians to allocate time for family-related activities and obligations, time for real social relationships, support from friends, partners, and families would help to improve resilience of veterinarians against mental disruptions (5, 22). Therefore, the work-life balance, focusing on nurturing social ties and recreational physical activity should be addressed in preventive programs for both, students, and practising veterinarians.

In our survey, some participants highlighted challenges related to gender issues as a notable concern. For instance, several veterinary students expressed concerns about gaining respect from customers as women, suggesting a perceived gender bias in client interactions. Additionally, some comments from students and veterinarians underscored broader systemic issues, with some noting disparities in how men and women are treated within the profession. Some veterinarians reported additional pressure felt by women, highlighting the need to surpass higher standards and the persistent undervaluation they face due to gender stereotypes, including concerns related to pregnancy. Notably, our survey sample reflected a higher proportion of women, both among students (85.8%) and veterinarians (72%), which underscores a gender imbalance within the field. These findings suggest a need for further exploration of gender dynamics and support mechanisms within the veterinary profession to address underlying inequalities and promote inclusivity.

The overall higher burden anticipated/experienced by female students/veterinarians is in line with a recent scoping review, highlighting that female veterinarians perceive a higher psychological workload compared to their male counterparts (5). In line with these findings, female students and veterinarians participating in the current study experienced a higher mental health burdened compared to their male colleagues (9, 10).

This study has some limitations. First, there's a significant potential for nonresponse bias, which may lead to either an overestimation or underestimation of the estimated/experienced stressors related to veterinary practice. It remains unclear whether students and veterinarians experiencing profound psychological distress were more inclined to participate in the questionnaire due to their vested interest in the topic or, conversely, less inclined due to factors such as reduced interest or energy, or social withdrawal. Second, all mental health indicators were based on self-reports and not confirmed by structured clinical or standardized interviews due to the online nature of the study. Third, the cross-sectional design of the study does not allow for causal conclusions. Lastly, it is worth noting that the questionnaire lacked inquiries designed to evaluate personality traits, family histories of mental illness, or other factors that could conceivably impact the perception of job-related stressors as well as mental health.

5 Conclusion

Results suggest that poor mental health in Austrian veterinarians is mainly associated with perceived financial worries, communication with clients and high workload. Comparisons between data from veterinary students and practicing veterinarians suggest that professional bodies and veterinary universities can play a vital role in raising awareness among students and veterinarians about the significance of mental health and overall well-being, while also encouraging them to allocate time for self-care activities. Implementing measures to limit excessive work hours and evening shifts could also prove beneficial. Considering the significant stress levels inherent in the veterinary profession and the evident impact of financial pressures, we recommend that veterinarians consider seeking guidance to develop a stress management strategy aimed at enhancing their stress-coping abilities and consider consultations with mental health and financial planning experts.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics committee of the University for Continuing Education Krems. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their electronic informed consent to participate in this study.

Author contributions

VN: Conceptualization, Data curation, Investigation, Methodology, Supervision, Writing – original draft. AG: Formal Analysis, Investigation, Methodology, Software, Writing – original draft. TP: Writing – review & editing. DB: Conceptualization, Data curation, Methodology, Writing – review & editing. RD: Conceptualization, Methodology, Writing – review & editing. CP: Writing – review & editing. EH: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2024.1389042/full#supplementary-material

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Assessment and Implementation of WOAH Day 1 Competencies (AID-1C): a cyclical methodology for curriculum harmonization with international standards

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Introduction: The World Organisation for Animal Health (WOAH) Day 1 Competencies for Graduating Veterinarians provide a standard framework to guide Veterinary Educational Establishments (VEEs) in improving their veterinary public health and population medicine curricula. However, pursuing a curriculum revision to incorporate these standards may be daunting, especially for institutions with limited resources or experience. This manuscript describes a methodology for targeted curriculum revision specifically focused on the WOAH Day 1 Competencies.

Phases of the AID-1 process: The Assessment and Implementation of WOAH Day 1 Competencies (AID-1C) is a six-step, cyclical, collaborative methodology that encompasses a series of tools and processes that help a VEE to evaluate their curriculum, identify and prioritize gaps, and develop and implement an action plan based on the results. The six phases of the AID-1C process include: (1) Assessment of the proficiency of the VEE's graduates in Day 1 Competencies using a structured Evaluation Tool; (2) A systematic curricular review and evaluation; (3) Identification and prioritization of interventions through a group problem-solving and prioritization exercise called Focus Forward; (4) Design and development of interventions to address identified gaps; (5) Curricular implementation; and (6) Monitoring and evaluation. The AID-1C methodology relies upon active involvement of senior students, recent graduates, faculty, instructional staff, and employers throughout the process.

Conclusion: The AID-1C methodology provides a systematic, participatory, collaborative approach that simplifies the planning and execution of the curricular revision, making a complex process more manageable. This enables VEEs to improve their curricula, while moving toward harmonization with WOAH standards. The result is a curriculum that allows a VEE to train well-rounded and competent veterinarians, with the requisite skills to support the veterinary services in their country.

KEYWORDS

curriculum evaluation, curriculum revision, competency assessment, WOAH day 1 competencies, veterinary public health, veterinary preventive medicine

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Introduction

Curriculum assessment and revision are critical activities that help veterinary educational establishments (VEEs)[1] ensure that they are graduating veterinarians who are well-equipped to meet current and future animal health challenges. There are many reasons that a VEE might choose to undertake curricular revision, including meeting institutional mandates, accommodating shifting administrative or professional priorities, addressing curricular drift, incorporating new pedagogical best practices, and assuring that materials reflect the latest scientific advances (1–4). Curriculum revision can take many forms, from large scale changes affecting the whole curriculum to more targeted interventions that are focused on a particular subject area.

This manuscript describes a methodology for targeted curriculum revision specifically focused on veterinary public health and population medicine. In a globalized society where infectious diseases can travel around the world in a matter of hours, having a veterinary workforce that is competent in these focus areas is critical to protect global health security (5–9). To support countries in improving the capacity of their veterinary workforce, the World Organization for Animal Health (WOAH) has outlined a series of non-clinical "Day 1 Competencies" (10) to prepare new veterinary graduates to effectively support veterinary regulatory and population health activities in their countries. These recommendations are also supported by a model curriculum that outlines key topic areas and when they should be taught in the curriculum (11).

The creation of these guidance documents in 2012–2013 represented an important step forward because they provide a clearly defined international standard for veterinary public health education. However, many VEEs needed to undertake significant curricular revisions to meet them, and this was a daunting task for faculty and administrators, especially those at institutions with limited resources or experience with curricular revision. Several examples exist of institutions conducting curriculum mapping to reach a preliminary assessment of how well their curriculum was aligned with the Day 1 Competencies (12, 13). However, using curriculum mapping as the sole method of evaluation, as these publications did, does not allow the VEE to assess the level of proficiency of their graduates, nor does it provide a mechanism for VEEs to identify and prioritize interventions to address gaps.

Therefore, there was a need for a standardized process that would allow VEEs to assess the competence of their current graduates and create a customized roadmap for moving toward compliance with the new standards. Because each individual VEE faces unique challenges, this process needed to be customizable and allow input from a wide range of local partners. It was also important that harmonization with the Day 1 Competencies be treated as an ongoing process rather than an endpoint, allowing VEEs to progress toward harmonization at a pace that was feasible for them and to adapt their plans in the future as the standards evolve.

To meet these needs, The Ohio State University College of Veterinary Medicine developed the *Assessment and Implementation of WOAH Day 1 Competencies* (AID-1C) methodology, a cyclical, collaborative methodology to help VEEs evaluate their curricula and move toward harmonization with WOAH standards using a systematic approach. The AID-1C methodology encompasses a series of tools and processes that help a VEE to evaluate their curriculum, identify and prioritize gaps, and develop an action plan based on the results. The methodology was originally developed for use at the University of Gondar in Ethiopia (14, 15), but it has recently been successfully applied in Southeast Asia, where it has been endorsed by the ASEAN Veterinary Statutory Body Network as a mechanism to implement a minimum accreditation standard in the region. Individual components of the methodology have also been adapted to help VEEs in South America and Central Asia to align their antimicrobial resistance curricula with the AAVMC/APLU AMR Learning Outcomes (16), demonstrating its flexibility and applicability in a variety of settings.

Conceptualization of the AID-1C methodology

In 2015, the University of Gondar and The Ohio State University were selected by WOAH to participate in the first Veterinary Education Twinning Program in Africa (14). In order to remain accountable to donors and other stakeholders, it was important to be able to describe and visualize the process that would be used to assess and improve the veterinary training program at University of Gondar. The AID-1C methodology was developed to formalize a process that evolved organically during the Twining Program. The details of how this process unfolded are described in the series of technical reports associated with the UoG-OSU Twinning program (17–21).

This manuscript describes the six phases of the AID-1C methodology (Figure 1), with examples of how they have been applied and adapted in different settings.

Phases of the AID-1C Methodology

Before beginning the AID-1C process, it is necessary to assemble the *Curriculum Revision Team* that will shepherd the VEE through the curriculum revision (15). This team should include faculty, instructors, and staff who are involved in the teaching of WOAH Day 1 Competencies throughout the curriculum. This group should be interdisciplinary and diverse, reflecting different generations, ranks, and genders, as well as any other characteristics that are relevant for that institution. Careful selection of these members is critical to help reduce bias, incorporate different perspectives, and generate innovative ideas, among many other benefits.

Phase 1—Assessment (Evaluation Tool)

The first phase of the AID-1C methodology is an evaluation of the proficiency of the VEE's graduates in the areas outlined in the Day 1 Competencies. Best practices in veterinary education indicate that the most effective way to assess student competence is direct assessment through structured examinations, in which the students demonstrate

1 The term Veterinary Education Establishment (VEE) is used by the World Organization for Animal Health (WOAH) to be more inclusive of different types of institutions that train veterinarians in different countries.

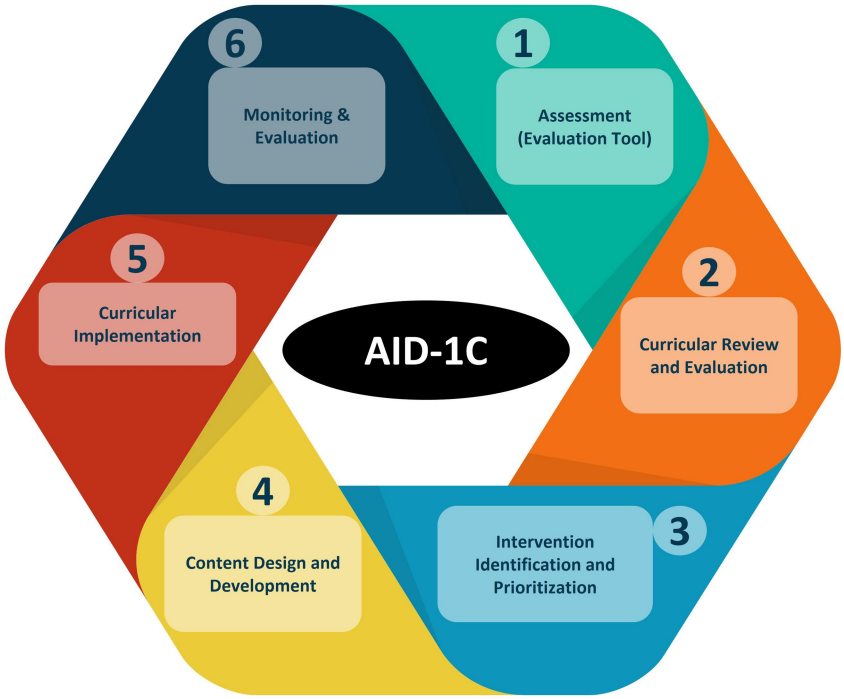

FIGURE 1
Cycle of the assessment and implementation of Day 1 competencies (AID-1C) methodology depicting the 6 stages of curriculum revision.

their ability to successfully execute the relevant skills (22–24). However, the Day 1 Competencies comprise a wide variety of topics, many of which are abstract and not conducive to practical demonstration (e.g., Competency 3.1: "Organization of Veterinary Services – having a general awareness of and appreciation for the delivery of National Veterinary Services as a global public good") (10). Therefore, evaluating all Day 1 Competencies through direct assessment of students is not always feasible, especially for VEEs in low- resource settings and those that have limited experience with this method of assessment.

Therefore, the AID-1C methodology relies upon senior students, recent graduates, faculty, and employers of the graduates to report on the perceived competence of the average new graduate based on their own experiences. Assessors are guided through a standardized, digital or paper-based survey ["The Evaluation Tool for WOAH Day 1 Graduating Veterinarian Competencies" (15)] in a facilitated Assessment Workshop. This Evaluation Tool consists of 175 questions that systematically evaluate the average new graduate's knowledge and ability to perform a variety of skills, ranging from epidemiological calculations to carcass inspection to risk communication.

For each question, the assessor can indicate if a particular topic is not covered in the curriculum, or if they are unable to confidently evaluate the graduates on a particular topic. If they decide that the topic is indeed in the curriculum, then they are asked to rate the average new graduate on a five-point scale, ranging from "not competent" to "highly competent." Competency levels are defined by the amount of assistance that a new graduate would require to complete the task on their first day after graduation.

Assessing competence indirectly in this manner reduces the resources required for the assessment, but it also means that assessor selection and facilitator training are essential to minimize bias. The inclusion of a diverse group of assessors representing students, recent graduates, faculty/instructors, and employers (from both the public and private sectors) helps to provide balance in the responses. Furthermore, careful evaluation of topics that have discordant results between these groups of assessors can yield important insights about potential areas for improvement. For example, if employers rate the graduates as proficient communicators, while the students self-report that they are not proficient, this discrepancy suggests the need for additional activities in the curriculum to build confidence in their communication skills. Having trained facilitators on hand during the workshop allows for the provision of additional examples or clarification as needed, which helps to improve the quality and validity of the data. The Evaluation Tool also includes open text fields for respondents to provide additional context to clarify their responses. The results of the assessment are always interpreted in conjunction with curriculum review (AID-1C Phase 2).

Phase 2—Curricular review and evaluation

A full review of the official curriculum provides important context to interpret the results of the competency assessment conducted in Phase 1. The curriculum review begins with curriculum mapping, in which the *Curriculum Revision Team* reviews the curriculum and course syllabi to determine if, when, and in what depth topics relevant to the Day 1 Competencies are covered. The timing of delivery is also evaluated for alignment with the WOAH Curriculum.

The team then compiles a list of topics that performed poorly in Phase 1, either because respondents *indicated either that* recent graduates were inadequately competent or that the topic was not taught in the curriculum. Each topic is cross-referenced with the

curriculum map to determine if and when the topic is taught, what pedagogical and assessment methods are used, and whether the topic is vertically integrated through the different years of the curriculum (see Figure 2). As part of this analysis, particular attention is paid to the amount and type of applied training associated with the different topics. If the team agrees that coverage of the topic in the curriculum is insufficient, they perform a preliminary assessment of how important the gap is to address; for instance, in some countries only government veterinarians write health certificates and they receive on-the-job training for this task, so incorporating this topic into the curriculum may not be considered a high priority.

While the AID-1C methodology is primarily focused on identifying gaps and areas for improvement, it is also important to dedicate time during this phase to note the topics that performed particularly well. Understanding the factors contributing to the success of these topics can inform the development of strategies to approach the teaching of those that did not perform as well. Clearly identifying which topics do not require further intervention also helps to reduce unnecessary expenditure of time and resources updating curriculum materials that already meet needs and conform with international standards.

Phase 3—Intervention identification and prioritization (Focus Forward)

Once the *Curriculum Revision Team* has identified key areas of concern based on integrating the results of Phases 1 and 2, internal and external partners are invited to participate in a two-day group problem-solving and prioritization exercise called Focus Forward. The ultimate goal of this exercise is to develop an action plan to improve the curriculum. This is achieved through five steps: (1) Socialization of assessment results, (2) Root cause determination, (3) Intervention identification, (4) Prioritization, and (5) Action Plan development.

Before the event, the coordinators organize the results of Phases 1–2 for presentation in themed sessions during the first day of the Focus Forward. A moderator introduces the gaps for each session (Step 1: Socialization of assessment results), then encourages participants to engage in small group discussions, in which they consider the reasons for the gaps and potential solutions to address them. Each group consists of 6 to 8 participants representing faculty, recent graduates, government officials, private sector representatives, and other boundary partners. Having these different perspectives helps to ensure that the groups can think creatively and identify innovative solutions, while also remaining rooted in a practical understanding of the academic program.

This process is facilitated by providing the participants with specially designed questions to guide the discussion. The initial questions focus on discussing the underlying causes and potential barriers associated with these problems (Step 2: Root cause determination). Each one of these questions is paired with a follow up prompt for participants to identify potential solutions and interventions (Step 3: Intervention identification) that address the causes identified by the participants in the previous step. Participants are also encouraged to identify the institutions or individuals who would be the key partners in implementing these interventions. If the moderators have experience addressing similar gaps in other

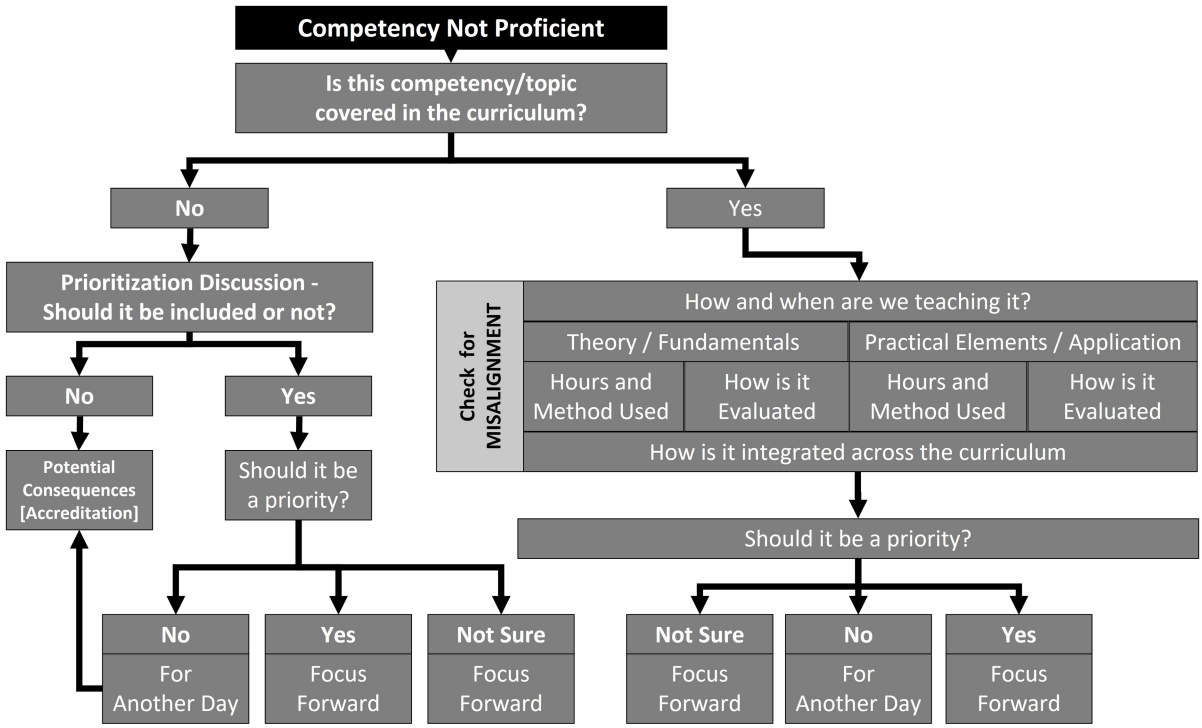

FIGURE 2
Algorithm for integrated interpretation of results obtained during Phase 1 (new veterinary graduate competency evaluation) and Phase 2 (curricular mapping) of the assessment and implementation of Day 1 competencies (AID-1C) methodology.

institutions, they may give examples of possible solutions during the introduction of this section, but the emphasis is on allowing the participants to identify solutions that are appropriate to their local context. The moderators also encourage the participants to propose solutions that are innovative but also feasible in the context of the VEE's needs and capabilities. These three steps take place during the first day of the Focus Forward workshop.

Following the activities on the first day, the event coordinators collect all the suggested ideas and organize them for the second day. During the second day, the moderator presents these ideas to the participants, who then use an anonymous real-time polling software to select the solution(s) that they feel should be prioritized (Step 4: Prioritization). The moderator instructs the participants to consider both the potential effectiveness of the intervention(s) and the feasibility (or likelihood of implementation) based on their current context or reality. After the event, the *Curriculum Revision Team* organizes the prioritized ideas and develops a short-term Action Plan (Step 5). For each identified gap, the Action Plan includes a detailed description of the corresponding intervention(s), including implementation strategy, timeline, and role assignments. This Action Plan is then shared with all participants and partners, including government agencies (e.g., Ministry of Education), other VEEs in the country, and the veterinary medical association(s).

Phase 4—Design and development

During this phase, the interventions from the Action Plan are developed and expanded upon. For example, new teaching materials are created in preparation for introducing or expanding coverage of Day 1 Competency related topics. In some cases, this can be as straightforward as developing a few new lectures, but VEEs are encouraged to view this as an opportunity to incorporate pedagogical best-practices. This should include innovative and engaging teaching methods that allow students to learn by doing or by teaching others. These novel approaches are especially critical for topics that performed poorly in the assessment despite already being present in the curriculum. This is because opportunities to apply knowledge through problem-based learning or field exercises allow students to build the confidence that they need to be successful in these areas after graduation.

For VEEs in low-resource settings or with less experience in performing curricular revision, this phase can be an excellent opportunity for collaboration with more experienced VEEs. Such institutions often have access to more resources and may have experience and/or expertise in addressing similar gaps. However, such relationships will only be successful if there is true collaboration; input from the faculty or administrators who will be implementing the interventions is critical to assure that they are relevant and feasible to implement. The more experienced VEEs can also provide support in the form of continuing education for faculty covering (1) foundational information about new subject matter, (2) design and development of teaching materials, and/or (3) new pedagogical best practices to improve their teaching and students' motivation.

Phase 5—Curricular implementation

During this phase, the *Curriculum Revision Team* carefully considers the practical details of how the recommended changes will be implemented. For example, they determine where in the curriculum new material will be incorporated, who will be responsible for teaching it, and what material will be eliminated to accommodate it, if necessary. They also plan how they will transition from the old curriculum to the revised version and identify resources needed to support the transition. The level of planning required varies substantially depending on how extensive the revisions are; when a curriculum undergoes major restructuring, it can be quite challenging to manage overlapping needs for resources (professors with a particular expertise, teaching spaces, etc.) between different cohorts. When new materials and/or methods are introduced, instructors may require more support and time to prepare for classes, which can put a strain on low-resource VEEs where instructional staff are already stretched thin.

The duration of this implementation period will vary depending on the institutional or national processes required to review and approve amendments to the curriculum. The level of approval required often depends on the extent of the curricular changes proposed; if the changes represent a small proportion of the curriculum and/or mostly affect individual courses, then the approval will likely take place at the institutional level, which typically takes one to two years. On the other hand, if the changes are substantial (e.g., moving a core course to a different year), then a government agency and/or accrediting body may need to review and approve the changes before they can be implemented. In these situations, approvals can take several years, depending on the country's legislative procedures.

Some changes can be implemented immediately, for example, modifying course content or implementing new teaching techniques. More extensive changes can only be implemented with a new cohort (e.g., moving a course to a different year, or changing core competencies) and therefore will take much longer to be fully implemented. As a result, this phase of the AID-1C methodology takes place on a much longer timescale than previous phases. It is usually necessary for multiple cohorts of veterinary students to progress through the program to allow the new curriculum to evolve and mature before the impact of the changes can be observed.

Phase 6—Monitoring and evaluation

The main aim of the Monitoring & Evaluation process is to allow VEEs to identify and address issues in real time, rather than waiting four or more years for a full evaluation after a cohort has completed the revised curriculum in its entirety. Realtime feedback should be collected from students, faculty, and administrators after the first few iterations of a new course or activity under the new curriculum. Feedback should be collected using multiple mechanisms customized for each group, including anonymous surveys and focus groups. In the case of students, standard teaching evaluation surveys need to be modified to include specific questions assessing the new teaching methods and/or content that were introduced into the course. These evaluations should be supplemented by small focus groups to assess student morale, motivation, and satisfaction with the changes. Evaluations delivered to faculty aim to identify any obstacles and challenges encountered in the delivery of the new content and to assess the faculty's perception of the value of the changes. Finally, administrators should be included in the evaluation process to determine the impact the new changes are having on the institution's logistics, function, and budget.

Restarting the cycle

After 2–3 cohorts have completed the new curriculum in its entirety, a full curriculum assessment should be repeated to determine how successfully the previously identified gaps or deficiencies have been addressed. Depending on the length of the VEE's curriculum, this could be as many as 8–10 years later. During this assessment, Phases 1 and 2 are repeated as described above. It is important to note that this repeat assessment can be subject to response shift bias (25). For example, at the University of Gondar, many of the topics targeted for intervention performed worse during a follow-up assessment. However, when more qualitative feedback was elicited, it appeared that the declining quantitative results could be attributed to greater awareness by the participants of the importance of the Day 1 Competencies and the room that still existed for improvement.

Example: Evaluation of student training in outbreak investigation

This section provides an example of the application of the AID-1C methodology to a specific topic, outbreak investigation, that represents a common challenge for many VEEs (including those in high-resource settings). Outbreak investigation is covered in the section of the Evaluation Tool pertaining to Epidemiology (WOAH Competency 2.1), but in reality, it incorporates subject matter from many different competencies, including Transboundary Animal Diseases (2.2), Zoonoses (including foodborne disease) (2.3), Emerging and Re-emerging Diseases (2.4), Food Hygiene (2.6), Management of Contagious Diseases (3.3), and Applications of Risk Analysis (3.5). The interdisciplinary and applied nature of this topic is one of the reasons that many VEEs struggle to teach it effectively, and the involvement of diverse partners in the AID-1C methodology is instrumental in assuring successful curriculum improvement.

Outbreak investigation is an example of a topic where there may be differences between groups in their assessment of new graduates during AID-1C Phase 1. Faculty may recall the extensive didactic instruction that they provide on this topic and indicate that new graduates are highly competent in outbreak investigation. Employers, by contrast, may feel that new graduates require substantial assistance and on-the-job training to apply this knowledge, and thus rate graduates as insufficiently or not competent. Because the Evaluation Tool stratifies results by participant group, such discrepancies are easily detected, and the subject can be flagged for more detailed review. Upon review of the curriculum in AID-1C Phase 2, it often becomes apparent that, although outbreak response is included in the curriculum, the coverage is primarily didactic and theoretical, with no opportunities for practical application. If curricular assessment were only based on curriculum mapping, without the additional perspective provided by the Assessment Workshop, it is very likely that this imbalance between theoretical and practical training would be missed.

If a lack of practical training in outbreak investigation is a gap that emerges from Phases 1 and 2, the issue is then presented to participants in the Focus Forward process (Phase 3), where internal and external partners work together to identify opportunities to deliver the material in a more dynamic and practical way. The involvement of external partners at this stage is important for two reasons: (1) their real-world experience provides valuable perspectives on what content should be included/emphasized and (2) their involvement at the inception of an intervention ensures that they are invested in the process and increases the likelihood that they will offer to assist with future stages.

During the design and development phase (Phase 4), many VEEs discover that their faculty may not have the expertise to design, deliver, and/or implement practical teaching methods, such as tabletop or field exercises, without external support. Common challenges include insufficient subject matter knowledge, limited real-life experience, and/or lack of expertise with hands-on teaching methods. Institutions that are less familiar with these methods of teaching often benefit from partnering with a more experienced VEE that can provide continuing education and mentorship to faculty as they develop new materials. Involving working professionals can also be very beneficial at this stage because the design of an effective and realistic tabletop or field exercise relies on input from individuals with lived experience. Collecting feedback from individuals who use these skills in their daily work, both in the public and private sectors, helps ensure that exercises are realistic and reflect current government or industry practice. These professionals can also help to identify priority issues for their organization or veterinary services; for example, suggesting a specific disease to be the focus of an outbreak exercise. In some cases, they may even be able to provide real scenarios that can serve as the basis for development of an exercise.

Implementation (Phase 5) of practical content to teach outbreak investigation can be challenging because hands on exercises typically require more resources than didactic teaching in the classroom. This includes physical materials (e.g., personal protective equipment, sampling supplies), but also access to appropriate facilities (e.g., farms, diagnostic labs) and qualified facilitators. The partnerships formed in earlier stages of the AID-1C process can be useful during this stage because working professionals often make good facilitators, and senior leaders from the public or private sector may be able to offer support in the form of access to facilities or supplies.

The AID-1C methodology's emphasis on continuous monitoring and evaluation (Phase 6) means that VEEs have the opportunity to identify and address problems in real time. This is especially important in the implementation of practical and applied content because VEEs might not have significant prior experience with these methods. Therefore, it is essential to conduct evaluations immediately after each new intervention or activity to document students' and faculty's experiences and identify opportunities for improvement in real time. This active monitoring allows for continuous improvement as the changes in the new or updated curriculum are implemented. In addition to informing future iterations of the hands-on activities, monitoring student performance during practical exercises can help to identify opportunities to improve the coverage of related materials earlier in the curriculum. Because incorporating opportunities for practical application often makes student knowledge gaps more apparent, it is not uncommon for reports of perceived competency to temporarily decrease during this phase.

Discussion and conclusions

The development of the WOAH Day 1 Competencies represented an important step forward because it provided a standard framework

to guide VEEs in improving their veterinary public health curricula to support the veterinary services in their countries. Having an established process for collaboratively identifying, prioritizing, and addressing gaps can help galvanize institutions to begin the process of harmonizing their curriculum with WOAH standards.

The AID-1C methodology breaks down a very complex curricular revision and update process into manageable steps. Each phase has a discrete beginning and end, which helps the VEE community to stay motivated, as they feel that they are making progress. This methodology is supported by a suite of tools (e.g., Evaluation Tool), processes (e.g., Focus Forward), and defined deliverables (e.g., Action Plan) at each phase, which simplifies the planning and execution of the curricular revision, making a complex process more approachable.

Updating and improving the curriculum is a multiyear process that requires inputs from a large number of people. Therefore, it is essential to have a structured process that provides a roadmap with clear steps and outcomes. Because of the long period over which this process unfolds, there is likely to be leadership turnover; this is especially common in countries outside of the USA where the deans and administration often change every 4 to 6 years. Having a well-defined roadmap, as described in the AID-1C methodology, helps to maintain direction and momentum in the curricular revision process. For example, at the University of Gondar, this structured methodology allowed the curricular revision process to move forward as planned under the leadership of three different deans, four university administrations, and two national governments. A key benefit of the AID-1C methodology is that it assists in maintaining continuity across different administrations and changes in the VEE.

Another benefit of this methodology is that it was designed to be participatory and collaborative. Throughout the process, the input of external partners is critical to provide a broader and more diverse perspective when evaluating and improving the curriculum. For example, during the assessment (Phase 1), future employers and other key partners from both the public and private sectors are included to help identify gaps and issues that might be missed if only VEE internal participants were included. These external partners are also included in the identification and prioritization of interventions (Phase 3). This helps to ensure that the solutions identified are practical and have the support of the VEE's external partners. This buy-in is key during the implementation step (Phase 5), where external partners are asked to be part of the solution. This could include providing instruction in a very specialized topic or their area of expertise (e.g., how to prepare official health certificates), mentoring students through field placements, and/or facilitating access to other government or private industry opportunities. This collaborative approach during the curricular revision process also helps to build bridges between students and future employers.

While the Day 1 Competencies serve as a unifying standard for VEEs around the world, it is important to acknowledge that each VEE is unique and will approach the implementation of this standard in different ways. For this reason, the AID-1C methodology provides a general roadmap but is not prescriptive; it is intended to be modified to suit each VEE's unique circumstances. While advisors from other more experienced VEEs may provide mentorship and consultation regarding the implementation of the AID-1C methodology, the assessment and prioritization are always done by local partners who understand the context in which the VEE's graduates will be expected to work.

In its current form, the AID-1C methodology is designed as a tool to support focused evaluation of non-clinical competencies. However, it could potentially be adapted to assess other whole-curriculum competency frameworks (e.g., those produced by the Association of American Veterinary Medical Colleges (26) or the European Association of Establishments for Veterinary Education) (27). Since the Assessment phase (Phase 1) of the process was developed specifically to support the evaluation of nonclinical competencies (15), this phase would likely need to be modified to reflect established best practices in the evaluation of clinical competencies [e.g., objective structured clinical evaluation (22–24)].

In conclusion, the AID-1C methodology provides a systematic, collaborative approach through a series of tools and processes that help a VEE evaluate their curriculum, identify, and prioritize gaps, and develop an action plan. This methodology helps VEEs improve their curricula and move toward harmonization with WOAH standards. The result is a curriculum that allows the VEE to train well rounded and competent veterinarians, with the requisite skills to support the veterinary services in their country.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author. Requests to access the datasets should be directed to AH, hoet.1@osu.edu; AMB, berrian.4@osu.edu.

Author contributions

AH: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing. SS: Methodology, Project administration, Writing – original draft, Writing – review & editing. AMB: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. ALB: Methodology, Project administration, Writing – original draft, Writing – review & editing. IG: Project administration, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Assessment of health problems of sheep and goats based on ante-mortem and post-mortem inspection at Addis Ababa Abattoir, Ethiopia

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Introduction: Ethiopia has a rapidly growing small ruminant sector, which faces low productivity due to husbandry practices and poor health condition of the animals. A study was conducted in Ethiopia's largest municipal abattoir with the objective to assess the health problems of sheep and goats presented for slaughter using standard ante-mortem and post-mortem methodology.

Methods: A cross-sectional study using systematic random sampling was conducted on 384 sheep and 384 goats from January to July 2014.

Results: Soiled skin (69.1%), poor body condition (24.3%), and nostril discharge (19.5%) were common among both species at ante-mortem examination. Gross lesions were frequent in livers (39.7%) and lungs (37.2%), while pneumonia (18.1%) and adhesions (13.8%) were frequent in the lungs of sheep and goats, indicating stress-related illness. Parasitic lesions, especially fasciolosis (19.3%) and hydatid cysts (8.1%) were significantly more common in sheep livers (p 0.05). The direct financial loss from lesions in both species was 1,077,015 ETB or 53,851 USD per year, most of which was estimated to occur from carcass bruising.

Discussion: The findings indicate that reducing parasite burden and preventing carcass bruising through improved handling could significantly increase the profitability of the small ruminant meat sector in Ethiopia.

KEYWORDS

Ethiopia, goats, lesion, meat inspection, parasites, sheep, small ruminants

1 Introduction

Ethiopia has one of the largest small ruminant populations in Africa, with approximately 42.9 million sheep and 52.5 million goats (1), which account for approximately 10% of Africa's and 4% of the world's small ruminant population (2). This resource plays an important role in the livelihood of smallholder farmers throughout Ethiopia. A recent study estimated that the small ruminant biomass constitutes about 13% of the total livestock biomass in Ethiopia (3). There has been a rapidly increasing demand for small ruminant meat in Ethiopia, both for domestic consumption and for export trade. Nearly 86% of the country's 93 million USD meat

export revenue was made up of small ruminants in 2018/2019 (4). The small ruminant sector in Ethiopia has a large potential to meet the growing demand, and the Ethiopian government aims to further increase the production and export of small ruminant meat. However, Ethiopia's earnings from small ruminant products are limited by problems with infrastructure, poor slaughter hygiene, high disease burden, and lack of trained personnel. Every year, significant losses occur from diseases, death of animals, and condemnation of organs and carcasses at slaughter (5). As poor health is a major contributor to low productivity of the small ruminant sector in Ethiopia, an improved understanding of the health problems is needed to support production policies and interventions.

The small ruminant meat value chain in Ethiopia includes producers, traders, handlers, and consumers of small ruminants and their products. Abattoirs are an essential node and are a source of information that can help monitor diseases and provide feedback to value chain actors based on data collected during meat inspection. The aim of meat inspection is to provide safe and wholesome meat for human consumption, which involves ante-mortem and post-mortem examination. Ante-mortem inspection identifies diseased and injured animals, while post-mortem examination reveals abnormalities and pathological processes resulting from various diseases in the carcass (6). Therefore, ante-mortem and post-mortem examinations provide useful information about the general health conditions and the presence of various diseases of the examined animals. Hence, the gathered information can help design interventions to improve the health, productivity and husbandry of the animals (7). Furthermore, abattoir data can assist in planning strategies to protect the public from zoonotic hazards (8).

A considerable number of abattoir studies have been conducted in Ethiopia. Several of these studies focused on lesions and conditions in cattle (9, 10) or on parasitic causes such as hydatidosis (11). Fewer studies focused on organs and carcass condemnation rates and associated economic losses in small ruminants in different export abattoirs in Ethiopia (5, 8). The target populations for the export abattoir-based studies were mostly limited to male sheep and goats from the lowlands that had been carefully selected and deemed suitable for slaughter at an export abattoir (and thus expected to be in better overall health condition than the general small ruminant population). A survey of slaughter animals in a major public abattoir that caters to the domestic market would give a better estimate of the existing health problems and productivity constraints of the country's small ruminant population. Therefore, this study was carried out with the objective to improve our understanding of the health problems of sheep and goats slaughtered in Ethiopia's largest municipal abattoir through comprehensive ante-mortem and post-mortem inspection procedures. We also estimated the direct economic loss resulting from the presence of gross lesions in organs and carcasses of sheep and goats.

2 Materials and methods

2.1 Study location

The study was conducted at the Addis Ababa Abattoir Enterprise (AAAE), which is the biggest municipal abattoir in Ethiopia, providing 85% of the meat requirements of the capital city's residents (12). The AAAE is in the capital city of Addis Ababa and has the capacity to slaughter up to 1,000 sheep and goats per day (12). Animals are brought from the Central Highlands, passing through a hierarchy of markets. The Central Highlands region is located at 2,000–2,560 m above sea level with an average annual rainfall of 1,100 mm. Small ruminant husbandry in the Central Highlands is characterized by extensive smallholder mixed crop-livestock production system (11, 13). Small ruminants are kept mainly at communal grazing within cereal crop areas. In this system, the average flock size per household is three (sheep), or four (goats) animals (3).

2.2 Study design, sample size determination and sampling technique

A cross-sectional study involving ante-mortem and post-mortem inspection was conducted from January to July 2014. All age groups and both male and female sheep and goats brought from the Central Highlands to AAAE for the purpose of meat production were eligible for inclusion in the study. In order to minimize sampling multiple animals from the same herd, systematic random sampling was used by selecting every fifth eligible animal, based on the average herd size of 3–4 animals. Different lesions were expected to have different frequencies of occurrence. An expected prevalence of 50% was used in the sample size calculation, because it yielded the largest sample size among all other expected frequencies. Thus, the sample size required was calculated from expected prevalence of 50% with defined precision of 5% and level of confidence of 95% (14). Therefore, the total sample size was 768 small ruminants, including 384 sheep and 384 goats. The selected animals were identified using scotch tape, numbered using waterproof marker, and were followed for the post-mortem inspection.

2.3 Study methodology

All pre-slaughter examination of small ruminants was conducted by a qualified veterinarian (Tizeta Bekele) in the lairage following standard ante-mortem inspection procedures (Table 1). The age of each animal was determined based on standard methodology following the eruption of one or more incisor teeth (20). Accordingly, animals were classified as young (goats <1 year; sheep <1.5 years) or adult (goats >1 year, sheep >1.5 years). Body condition score was determined following the guidelines of the Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP) guidelines (20).

All the small ruminants that had been examined by ante-mortem inspection were also thoroughly examined during post-mortem inspection. During this process, carcasses, and different organs (heart, lung, liver, and kidney) were thoroughly inspected by visualization, palpation and by making incisions as needed to look for the presence of abnormalities. Pathological lesions were differentiated and judged according to standard meat inspection guidelines (21, 22).

2.4 Estimation of direct economic loss

The analysis of direct economic loss was based on the annual slaughter rate of the abattoir, average market prices in the local market

TABLE 1 Description of the clinical protocol for individual ante-mortem inspection of sheep and goats.

Clinical parameters/signs	Scores/outcomes
General behavior	0: Normal; 1: Abnormal (excessive excitability or severe depression)
Rectal body temperature (15)	0: Normal sheep: 38.3–39.9°C; normal goat: 38.5–39.7°C
	1: Higher or lower than normal
Heart rate (16)	0: Normal: sheep and goats 70–80 per minute
	1: Higher or lower than normal
Respiration rate (16)	0: Normal: sheep and goats 16–34 per minute
	1: Higher or lower than normal
Oral lesions	0: Absent; 1: Present (ulcers)
Mucous membranes	0: Normal; 1: Abnormal (pale, dry, yellow)
Eye defects	0: Absent; 1: Present
Nostril discharge	0: Absent; 1: Present (thick, white/yellow/bloody fluid from nose)
Lameness (17)	0: Normal to mild (gait is normal); 1: Moderate to severe (gait is affected)
Body condition score (15)	0: Starving, 1: Very thin, 2: Thin, 3: Moderate, 4: Fat and 5: Very fat
Skin lesions (18)	0: Absent; 1: Present (hair loss, wounds, swelling)
External parasites	0: Absent; 1: Present (lice, fleas, ticks)
Presence of tag on skin (19)	0: No tag – No visible fecal material and/or soil on the hair coat; 1: Some tag present – Some degree of matted fecal material and/or soil; 2: Medium tag – Intermediate degree of matted fecal material and/or soil; 3: Heavy tag – Large aggregates of matted fecal material and/or soil

and the gross lesion frequencies of specific organs and carcass. Financial losses were calculated in terms of Ethiopian Birr (ETB) in view of the exchange rate at the time of the study (1 ETB = 0.05 USD). The annual slaughter rate was estimated from retrospective abattoir records which was 34,834 (12). Based on the current information obtained from the butcheries, the local market prices of heart, lung, liver and kidneys of sheep and goats were 2 ETB (0.1 USD), 3 ETB (0.15 USD), 5 ETB (0.25 USD), and 3 ETB (0.15 USD), respectively and that of carcass for both species of animals were 1,260 ETB (63.0 USD) per 12 kg. The direct loss was thus computed according to the formula as follows (23):

$$EL = \Sigma srx \text{ X } Coy \text{ X } Roz.$$

Where: EL = Annual direct economic loss estimated due to organ and carcass condemnation.

Σsrk = Annual sheep / goats slaughter rate of the abattoir.

Coy = Average cost of each sheep or goat s heart / lung / liver / kidney and carcass.

Roz = Gross lesion frequencies of sheep or goats / heart / lung / liver / kidney / and carcass.

2.5 Data analysis

Data were entered into Microsoft Excel spreadsheet (Microsoft, Redmond, WA, United States). Descriptive statistics and proportions expressed as percentages were used to analyze the data on health parameters. The Pearson chi-square test was used to assess the significance of association between species and various abnormalities/lesions, using standard statistical software (STATA IC13, StataCorp, College Station, TX, United States). A *p*-value less than 0.05 was considered statistically significant.

3 Results

3.1 Ante-mortem inspection

A total of 786 small ruminants (384 sheep and 384 goats) were subjected to ante-mortem inspection (Table 2). The presence of skin tags (medium to heavy tag; 69.1%), poor body condition (BCS < 3; 24.3%) and nostril discharge (19.5%) were the most encountered abnormalities. At least 10% of the animals also exhibited elevated heart rate (14.1%), elevated body temperature (10.5%), and increased respiratory rate (18.4%). A significantly higher proportion of sheep (22.1%) than goats (14.6%) exhibited respiratory abnormalities.

3.2 Post-mortem results and economic loss assessment

All animals that had been examined by ante-mortem inspection were subjected to post-mortem examination by a qualified veterinarian (Tizeta Bekele). Therefore, a total of 786 small ruminants were thoroughly examined after slaughter, including 186 young and 198 adult sheep, as well as 156 young and 228 adult goats. From the total organs examined in both species, gross lesions/diseases were most frequently detected in the livers (39.7%) and lungs (37.2%).

TABLE 2 Summary of abnormalities encountered during ante-mortem inspection.

Ante-mortem parameter	Number and proportion (%) of animals exhibiting parameter		
	Sheep (n = 384)	Goats (n = 384)	Total (n = 768)
Abnormal behavior	20 (5.2)	15 (3.9)	35 (4.6)
Abnormal temperature	**47 (12.2)**	34 (8.9)	**81 (10.5)**
Abnormal heart rate	**50 (13.3)**	**58 (15.1)**	**108 (14.1)**
Abnormal respiration rate*	**85 (22.1)**	**56 (14.6)**	**141 (18.4)**
Oral lesions	2 (0.5)	0 (0)	2 (0.3)
Abnormal mucus membranes	15 (3.9)	9 (2.3)	24 (3.1)
Eye defect	1 (0.3)	3 (0.8)	4 (0.5)
Nostril discharge*	**94 (24.5)**	**56 (14.6)**	**150 (19.5)**
Lameness/locomotion problems	2 (0.5)	2 (0.5)	4 (0.5)
Poor body condition score	**97 (25.2)**	**90 (23.4)**	**187 (24.3)**
Skin lesions	5 (1.3)	5 (1.3)	10 (1.3)
External parasites	3 (0.8)	3 (0.8)	6 (0.8)
Skin tags	**281 (73.1)**	**250 (65.1)**	**531 (69.1)**

*Statistically significant difference ($p < 0.05$) in occurrence of abnormality between sheep and goats. Commonly observed conditions (>10%) were highlighted in bold.

Gross lesions were less common in hearts (3.9%), kidneys (0.65%) and carcasses (2.2%) for both species. Overall, lesions in the livers (51.0%), lungs (48.7%) and carcasses (3.6%) of sheep were significantly more common than those in in goats (28.4, 25.8, and 0.8%, respectively). The observed lesions and their respective frequencies in sheep and goats were summarized in Table 3.

Out of the total livers inspected in both species, the most common gross pathological conditions were fasciolosis (12.0%), hepatitis (8.9%) and hydatid cysts (5.2%). There was no statistically significant difference for all types of liver lesions between age groups ($p = 0.586$) but there was statically significant difference between species ($p < 0.001$). Specifically, parasitic lesions due to fasciolosis (19.3%), hydatid cysts (8.1%) and *Cysticercus tenuicollis* (4.9%) were significantly more common in the livers of sheep (Figure 1). Liver calcification (6.0%) was also more common in sheep.

The major gross pathological conditions observed in the lungs were pneumonia (18.1%), adhesions (13.8%), and hydatid cysts (6.1%) in both species. There was no statistically significant difference for all causes of lung lesions between age groups ($p = 0.781$) but there was statistically significant difference between species ($p < 0.001$). Specifically, adhesions (17.4%) and pneumonia (22.9%), as well as parasitic lesions due to hydatid cysts (9.1%) and lung worms (3.9%) were significantly more common in the lungs of sheep (Figure 2).

Gross lesions in hearts were rare and included adhesions (3.1%), pericarditis (0.5%) and hydropericardium (0.3%) for both species. There was no statistically significant difference for all types of heart lesions between age groups ($p = 0.168$) and species ($p = 0.10$).

Gross pathological lesions were very rarely detected in the kidneys and included nephritis (0.3%), hemorrhage (0.3%) and calcification (0.1%) for both species. There was no statistically significant difference for all types of kidney lesions between age groups ($p = 0.825$) and species ($p = 0.999$).

Bruising (2.1%), and less commonly, hematoma (0.1%) were observed in the carcasses of sheep and goats. There was no statistically significant difference for all causes of carcass lesions between age groups ($p = 0.114$). However, the frequency of overall carcass injuries was significantly higher in sheep compared to those in goats ($p = 0.007$). Specifically, bruising was four times more common in sheep (3.4%) compared to goats (0.8%).

The annual direct economic loss from sheep and goats combined was estimated to be 1,077,015 ETB or 53,851USD per year. Most of this loss was due to carcass bruising (89.6%).

4 Discussion

This study investigated the presence and extent of health problems of Ethiopia's sheep and goat population by use of a standard meat inspection methodology in the country's largest municipal abattoir. Such data are useful to realize health problems in a specific local population. Ante-, and post-mortem inspection may then not only serve directly to provide causes for complete or partial condemnation of carcasses, but they also deliver data for supervision of the food chain and as basis for subsequent interventions. Therefore, results of this study will be very useful to stakeholders and all value chain actors in designing and prioritizing interventions. Knowledge gaps were also identified, which will assist in the design of future research activities related to the small ruminant meat industry.

The present findings indicated that livers had the highest proportion of gross lesions with an overall lesion prevalence of 39.7%. This finding is comparable to studies from export abattoirs in Ethiopia, where overall liver condemnation rates for small ruminants were in the range of 32.4 to 46.7% (5, 8). However, this study detected fasciolosis in 19.3% of all sheep livers examined, which is a much higher rate than those reported from the export abattoirs, which were in the range of 4.7 to 6.9% (5, 8). The reason for the higher rate of fasciolosis in this study compared to those from the export abattoirs can be differences in husbandry practices (i.e., application of anthelminthics) or differences in agro-ecologies. As sheep and goats acquire the infection when they consume the infectious stage of the parasite from marshy pastures, animals originating from moist highland areas (target population for present study) might be at a higher risk compared to those coming from the dryer lowlands (target population for export abattoir-based studies). A field-based study in 1993 estimated the annual economic loss associated with ovine fasciolosis in

TABLE 3 Summary of post-mortem lesions and associated economic losses.

Organ	Lesion	Number and proportion (%) of lesions			Annual loss (ETB)	Annual loss (USD)
		Sheep (*n* = 384)	Goats (*n* = 384)	Total		
Liver	Overall	196 (51.0)	109 (28.4)	305 (39.7)	69,146	3,457
	Adhesion	19 (4.9)	17 (4.4)	36 (4.7)		
	Hepatitis	38 (9.9)	30 (7.8)	68 (8.9)		
	Calcification*	23 (6.0)	10 (2.6)	33 (4.3)		
	Fasciolosis*	**74 (19.3)**	18 (4.7)	**92 (12.0)**		
	Stilesia hepatica	1 (0.3)	4 (1.0)	5 (0.7)		
	Hydatid cyst*	31 (8.1)	11 (2.9)	42 (5.2)		
	*Cysticercus tenuicollis**	19 (4.9)	10 (2.6)	29 (3.8)		
	Abnormal coloration	3 (0.8)	0	3 (0.4)		
Lung	Overall	187 (48.7)	99 (25.8)	286 (37.2)	38,875	1,944
	Adhesions*	**67 (17.4)**	**39 (10.2)**	**106 (13.8)**		
	Emphysema	5 (1.3)	1 (0.3)	6 (0.8)		
	Pneumonia*	**88 (22.9)**	**55 (14.3)**	**143 (18.1)**		
	Hydatid cyst*	35 (9.1)	12 (3.1)	47 (6.1)		
	Lung worm*	15 (3.9)	3 (0.8)	18 (2.3)		
	Cysticercus tenuicollis	1 (0.3)	0	1 (0.1)		
Heart	Overall	15 (3.9)	15 (3.9)	30 (3.9)	2,717	136
	Adhesions	12 (3.1)	12 (3.1)	24 (3.1)		
	Pericarditis	2 (0.5)	2 (0.5)	4 (0.5)		
	Hydropericardium	1 (0.3)	1 (0.3)	2 (0.3)		
Kidney	Overall	3 (0.8)	2 (0.5)	5 (0.65)	679	34
	Nephritis	1 (0.3)	1 (0.3)	2 (0.3)		
	Hemorrhage	1 (0.3)	1 (0.3)	2 (0.3)		
	Calcification	1 (0.3)	0	1 (0.1)		
Carcass	Overall	14 (3.6)	3 (0.8)	17 (2.2)	965,598	48,280
	Bruising*	13 (3.4)	3 (0.8)	16 (2.1)		
	Hematoma	1 (0.3)	0	1 (0.1)		
Total loss					1,077,015	53,851

*Statistically significant difference ($p < 0.05$) in occurrence of abnormality between sheep and goats.
ETB, Ethiopian Birr; USD, United States Dollar. Commonly observed conditions (>10%) were highlighted in bold.

the Ethiopian highlands to be 48.4 million Ethiopian Birr or 2.42 million USD (24). As the highland sheep population appears to be a high-risk group for fasciolosis in Ethiopia with serious economic consequences, pasture management and snail control, along with strategic drenching with flukicide should be preferentially targeted to this population, to effectively reduce the disease burden and associated financial losses due to fasciolosis. The implementation of this comprehensive approach, however, may provide challenging in the small ruminant value chain in Ethiopia.

The prevalence of hydatidosis in both the livers (8.1%) and the lungs (9.1%) of sheep were also higher in the current study compared to those reported from the export abattoirs, with rates of 0.9–1 and 3.3%, respectively (5, 8). The high prevalence of hydatidosis detected in this study in sheep organs has important public health significance. The adult form of the parasite, *Echinococcus granulosus*, is a small tape worm of dogs (16), but its occurrence and infection dynamics in the Ethiopian dog population is not well known. The larval stage, referred to as hydatid cyst, is found in sheep and goats and in many other intermediate hosts including humans (16). Studies indicated that human hydatidosis is prevalent in different regions of Ethiopia (25, 26), however more studies are needed to determine its prevalence and to delineate high risk areas in the country. Larval tapeworm infections have been reported to be common in the Ethiopian highland sheep population (25, 27) due to conditions that perpetuate the life cycle of the parasite, including: (1) lack of deworming of dogs; (2) stray dogs and foxes have access to offal; (3) presence of freely roaming dogs on grazing land and (4) backyard slaughter of sheep. Dog populations are relatively scarce in the lowlands, which may explain the lower prevalence of hydatidosis reported from export slaughterhouses that source their animals from the lowlands. Prevention of larval tapeworm infection in sheep would entail controlling tapeworm infection in dogs, stray dog control, and preventing dogs from accessing sheep carcasses.

FIGURE 1
Cysticercus tenuicollis in the liver of sheep.

FIGURE 2
Hydatid cysts in the lung of sheep.

In this study, sheep had a higher proportion of parasitic lesions than goats, and lesions due to fasciolosis, hydatid cysts and *Cysticercus tenuicollis* were significantly more common in the livers of sheep. This finding is in agreement with another study conducted at Addis Ababa abattoir among sheep and goats, which reported an overall higher prevalence of hydatidosis in sheep (19.9%) than in goats (16%) (11). Another study in Tanzania also reported higher prevalence of hydatidosis in sheep than in goats (28). The higher infection rate of sheep may be due to differences in feeding habits. Sheep are grazers while goats are browsers, therefore sheep have a higher chance of being exposed to the parasite (11).

Parasites such as *Stilezia hepatica*, *Cysticercus tenuicollis* and lungworms were also found in target organs, but their prevalence was less than 5% in this survey. These parasites do not have public health importance; the direct economic losses they cause are related to organ condemnation due to aesthetic reasons (8). The indirect economic losses related to these parasites could be several magnitudes higher compared to the direct losses due to organ condemnation, because infection with these parasites significantly reduces the animal's overall productivity (16). Therefore, reducing the disease burden from these parasites would have great economic benefits.

In this study, parasitic lesions were most commonly detected in the livers and lungs of both sheep and goats. This can be explained by the life cycle of parasites such as *Echinococcus*, whose migrating oncospheres enter the capillaries of these two organs first, before any other organ is involved (29). Lesions were detected in 37.2% of the lungs in this study for both species, which is comparable to the findings from an export slaughterhouse (41.7%) (8), with pneumonia being the most common lung lesion in the present study (18.1%) and in the above-mentioned export abattoir study (26.4%). Respiratory disorders were also commonly noted during the pre-mortem examination. Other studies have also found a high prevalence of respiratory disease in small ruminants in Ethiopia (30). The high rate of respiratory illness in small ruminants in different source populations indicates a widespread problem. In Ethiopia, conditions during transport to the abattoir are stressful for the animals, as they walk long distances or are transported in overcrowded trucks not designed for animal transport, face inclement weather, and are not offered food, feed, and rest along the way (31). These stressful conditions are known to play a predisposing role in the development of respiratory illnesses that include severe diseases such as ovine pasteurellosis, peste des petits ruminants (PPR) and contagious caprine pleuropneumonia (16, 32). Considering the high morbidity and mortality associated with these respiratory diseases, the overall economic loss from respiratory illnesses could be very substantial to the small ruminant meat industry in Ethiopia. Therefore, reducing stressful conditions, particularly during transport, could have great financial benefits to the small ruminant value chain.

The total direct economic loss associated with gross lesions was estimated to be 1,077,015 ETB or 53,851 USD per year in this study. This estimate is significantly lower than the losses calculated from commercial export abattoirs, which estimated losses at a magnitude of 300,000 to 400,000 USD per year (5, 8). The reason for this difference is that the current study used local market prices for the calculation, which are considerably lower than the international market prices. The total economic loss, however, could be much

higher, because there are several indirect losses as indicated above, such as illnesses that reduce productivity, losses from poor carcass condition, and mortality on the farm and during transport, which were not included in the calculation.

Most of the direct economic loss was estimated to occur from carcass bruising (89.6%). Other studies also reported high losses due to carcass bruising (5, 8). For example, a study reported a bruising rate of 10.7% and associated loss of 13,016 ETB (651 USD) during the slaughter of 1,125 small ruminants in an export abattoir in Ethiopia. Bruising occurs during transport and handling, due to excessive use of sticks, improper transport vehicles, rough handling, and slaughter without stunning (8, 15). These reports consistently indicate that serious direct economic losses occur both from the domestic and from international markets due to carcass bruising. For example, a study conducted at a large public abattoir in Ethiopia on sheep and goats reported poor handling of animals, including beating of the body (87.7%), pushing (57.9%) and pulling (49.1%) of the animals by their handlers (15). These handling practices often resulted in animal distress and falls, which in turn result in carcass bruising. Therefore, improved handling of animals during transport and slaughter (for example, by training of stakeholders on proper handling of animals) could significantly increase the profitability of the small ruminant meat sector in Ethiopia. In consultation with the abattoir management and workers, we developed guidelines on improving animal welfare along the small ruminant value chain in Ethiopia (15).

Lastly, the presence of skin tags and poor body condition were common findings in both sheep and goats in this study and others (5, 8, 15). These problems are complex as they relate to poor nutrition and husbandry practices overall along the value chain, but they will need to be addressed for long-term growth of the small ruminant sector.

5 Conclusion

This study highlighted some of the major health problems of Ethiopia's sheep and goat population by use of a standard meat inspection methodology. Results indicated that a significant proportion of livers and lungs (particularly of sheep) had gross lesions due to parasites, some of which had public health significance. Respiratory abnormalities and pneumonia were common in both species indicating stress-related illness, which could be a cause of substantial economic losses. Most of the direct economic loss was estimated to occur from carcass bruising, suggesting that improved handling of animals could significantly increase the profitability of the small ruminant meat sector in Ethiopia.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The animal study was approved by Institutional Research Ethics Committee of the International Livestock Research Institute (Ref. No. IREC-2013-03). The study was conducted in accordance with the local legislation and institutional requirements.

Author contributions

TB: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft. BS: Data curation, Formal analysis, Project administration, Writing – review & editing. AH: Investigation, Methodology, Supervision, Writing – review & editing. RF: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. MB: Conceptualization, Project administration, Resources, Supervision, Validation, Writing – review & editing. DR: Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Exploring veterinary students' awareness and perception of zoonoses risks, infection control practices, and biosecurity measures in Ethiopia

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Universities and colleges are often regarded as playing a key role in educating veterinarians and animal health workers who advise farmers on herd health and animal husbandry. However, to date, studies examining veterinary students' knowledge of zoonotic diseases of public health importance and the source of this knowledge, as well as their preparedness to respond to these diseases, have focused on the Global North rather than the Global South. This study takes Ethiopia as a case study in exploring veterinary medicine students' knowledge of zoonosis risks, infection control practices and biosecurity measures, recognizing that it is imperative to reconcile national-level veterinary education curricula with emerging global trends, such as One Health-focused training. This training advocates for a collaborative, interdisciplinary response at local, national, and international levels to the adverse impact of zoonotic diseases on animal health and productivity, and human and environmental health. Data for this study were collected through a pre-tested online questionnaire administered to 154 veterinary students from several universities in Ethiopia. The findings of this study suggest veterinary students were aware of the public health risks posed by zoonoses and the important role that collaboration between the disciplines of human and animal health can play in addressing zoonoses and emerging health risks. However, students demonstrated poor knowledge of the need to adopt infection control measures (ICPs) and biosecurity measures to reduce occupational risks and prevent within and between herd transmission of infection. Moreover, students' vaccination rates against zoonotic diseases associated with occupational risks, such as rabies, were low. The results of this study suggest that there are currently gaps in Ethiopia's veterinary curriculum and that enhancing veterinary students' access to information regarding infection control practices and biosecurity measures could contribute to reducing their future occupational exposure to zoonoses. This study highlights the policy implications of the current veterinary medicine curriculum in Ethiopia and the scope for aligning the curriculum with important global initiatives, such as One Health-focused training.

KEYWORDS

veterinary training, one health, biosecurity measures, occupational risks, animal health

Introduction

Veterinarians contribute to global public health in the areas of prevention and control of animal diseases, emerging infectious diseases, zoonotic and non-zoonotic disease surveillance, food safety and security, environmental health, global health security, and basic and applied medical research (1). Veterinarians are engaged in various roles including herd health, animal husbandry procedures, disease screening and surveillance, vaccination, treatments and surgical procedures, providing advice to a range of stakeholders, and animal welfare management (2).

Universities and veterinary colleges educate veterinarians and animal health workers (1) to provide a solid clinical knowledge base and relevant diagnostic and surgical skills to solve a broad spectrum of health problems around the world, including but not limited to those involving animals (1, 3). Veterinary training equips practitioners with relevant skills to support and share responsibility for the protection of human health and well-being in diverse fields including food safety, environment, biodiversity, and bioterrorism preparedness (1). Historically, veterinarians have contributed to the prevention and control of epidemics such as bovine spongiform encephalopathy and foot-and-mouth disease in the United Kingdom, West Nile virus in the United States (1), and Rift Valley fever (RVF) in East Africa (4). These epidemics impacted human and animal health, the economy and societal well-being and were finally contained through the valuable contribution of veterinarians (1, 4).

In their day-to-day occupational activities, veterinary students may be exposed through their professionally supervised training process to zoonoses such as brucellosis, bovine tuberculosis, rabies, Hendra virus and Q-fever because of their close contact with infected and dead animals through ingestion and inhalation, via conjunctiva or physical contact (5–8). It is, therefore, crucial to train veterinary students in disease prevention and control through the adoption of infection control practices (ICPs) (6). ICPs are also referred to as personal biosecurity measures (9). Biosecurity measures are widely used to refer to a set of measures that stop the spread of disease onto or out of an area where farm animals are present (10). Generally, ICPs are any methods employed to stop a disease or infection from spreading across environments, animals and people (11), including those in direct or indirect contact at the farm level, such as fellow staff, farmers or their family members (6, 8). Similarly, animal health practitioners can serve as agents of disease transmission or as a bridge for disease as they move from one farm to another attending to sick animals (12). Although in other parts of the world, there has been research on ICPs, there is a paucity of studies in sub-Saharan Africa investigating veterinary students' knowledge, perceptions, and adoption of ICPs (13–16).

This study uses Ethiopia as a case study because veterinary training is growing in most emerging economies (16, 17). Training of animal health assistants in Ethiopia started in 1963 with a two-year diploma program and the first Faculty of Veterinary Medicine was founded in 1979 at Addis Ababa University (AAU) (17). There are now 10 universities accredited to offer veterinary medicine degree programs (18). As of 2006, Ethiopia had 616 veterinarians, 3,993 animal health assistants and animal health technicians, and 1,375 community-based animal health workers, with over 87% of the veterinarians and 98% of the animal health assistants and technicians working in the public sector which shows the need to train more skilled veterinarians given the vast size of Ethiopia landmass and large number of farmers they have to serve (16, 17, 19). Currently, the quality and access to animal health services is a major challenge for farmers in Ethiopia (19–22). There are just a handful of studies on the Ethiopian veterinary profession (16, 17, 19), and to the best of our knowledge, no recent study has investigated the training of veterinary medicine, the expected education outcomes, the exposure to zoonoses (zoonotic risks), adoption of ICPs and sources of information. This study, therefore, aimed to explore the knowledge of veterinary students in Ethiopia, regarding their zoonoses risks, ICPs and sources of information.

Methodology

This national survey of veterinary students was conducted via an online questionnaire between April and June 2021 and covered veterinary medicine students across all 10 universities across Ethiopia. This study was objectively investigating the training of veterinary students and as such did not cover other people involved in the veterinary world, including practicing veterinarians and lecturers. The questionnaire was designed based on a literature review of students' knowledge of occupational risks, knowledge of personal ICPs and sources of veterinary information (16, 19, 23–26). This study employed an online questionnaire to enable participants to answer questions at their convenient time. We relied on convenience and purpose sampling to reach as many students as we could due to the travel restrictions related to COVID-19 that were present at the time that this research was conducted.

The questionnaire was pre-tested with five veterinary students, and adjustments and corrections were made based on their feedback. The pre-tested questionnaire survey consisted of both open and closed questions with options for the students to add more information (see Supplementary material). The questions aimed at collecting demographic information such as place and year of study, the student's knowledge of occupational risks, knowledge of personal ICPs, and sources of veterinary information. The questionnaire was hosted by Survey monkey® and took 30 min to complete. For enrolment, a questionnaire link was sent to students by email via student associations, class representatives and other veterinary organizations. Additionally, with help from practicing veterinarians and student organizations, the link was shared on social networking sites like Facebook, X (formerly Twitter) and WhatsApp that students used. The study purposively looked for experienced students at an advanced level of veterinary studies mainly third-year to sixth-year, and automatically excluded those in lower levels of study as they were not exposed to practical training with live animals, tissues and/or were not working in farm or clinical settings.

The survey was designed as an opt-in survey whereby taking part was considered as signed consent. No personal data was collected in this survey as an ethical consideration to avoid participant identification and/or victimization. The survey questionnaire was deleted from the hosting website after the data collection phase was completed. This study had ethics clearance from the University College London Research Ethics Committee (UCL-REC) approval number 19867/001 and the Armauer Hansen Research Institute (AHRI) and ALERT hospital AHRI/ALERT Ethics Review Committee (AAERC) approval Protocol number PO-(46/14).

Data management and analyses

The data collected during the survey was downloaded as an Excel document. Statistical analyses mainly descriptive statistics were undertaken using R statistical software.

The research design, data collection, analysis and writing were done collaboratively by all the authors.

Results

Table 1 presents the demographic characteristics of the participating veterinary students across the various veterinary schools at Ethiopian Universities. In total 154 veterinary students took part in this study. The majority of respondents were male students. The majority of respondents were in their 5th year of training and already doing work placements.

Table 2 presents the veterinary students' perceptions of the risks of zoonoses, and the importance of collaboration across the animal-human health sectors to ensure good health in society. Students were aware of the risks of zoonoses and the important role of collaboration between human and animal health. The students were aware of the occupational risks that farmers, farm workers and veterinary professionals were exposed to when working and interacting with livestock. They were also aware of the food safety and disease risks faced by consumers of animal-source products. Finally, they thought that climate change could exacerbate the risk of zoonoses and drive the emergence of new zoonoses.

TABLE 1 Characteristics of participant veterinary students in this study ($n = 154$).

		n (%)
Average age	Years (mean ± SD)	24.8 ± 1.3
Gender	Male	102 (66.2%)
	Female	52 (33.8%)
Home region	Oromia Region	57 (37.0%)
	Harari Region	23 (14.9%)
	Sidama Region	9 (5.8%)
	Addis Ababa (city)	11 (7.1%)
	Southern Nations, Nationalities and Peoples' Region	12 (7.8%)
	Gambela Region	7 (4.6%)
	Somali Region	3 (2.0%)
	Dire Dawa (city)	6 (3.9%)
	Amhara Region	21 (13.6%)
	Afar Region	3 (2.0%)
	Benishangul-Gumuz Region	1 (0.7%)
	Tigray Region	1 (0.7%)
Year of study	3	22 (14.3%)
	4	26 (16.9%)
	5	79 (51.3%)
	6	27 (17.5%)
University	Addis Ababa University	21 (13.6%)
	Gambela University	1 (0.6%)
	Gonder University	34 (22.1%)
	Haremaya University	21 (13.6%)
	Hawassa University	7 (4.5%)
	Jijiga University	6 (3.9%)
	Jimma University	5 (3.2%)
	Mekelle University	3(1.9%)
	Samara University	5 (3.2%)
	Wolita Sodo University	25 (16.2%)
	Wollega University	26 (16.9%)

Knowledge perception and the use of infection control practices and biosecurity measures

When asked to define biosecurity which involved a choice of multiple answers for each respondent, 126 (81.8%) students replied it meant preventing the entry of pathogens or diseases onto a farm, 129 (83.8%) students thought it is managing diseases and/or pathogens within a farm, 120 (77.9%) students thought it was preventing the exit of diseases/pathogens from the farm, 103 (66.9%) students said it is the general security to prevent theft of animal, 85 (55.2%) students replied protecting workers from disease and only 4 (2.6%) students were unsure of the definition.

Table 3 presents a summary of veterinary students' knowledge and adoption of ICPs and biosecurity measures for disease prevention. The students were aware of the risks associated with medical waste. They cleaned their hands after touching animal tissue, and fluids and properly disposed of veterinary wastes such as needles and razors. Although students were vaccinated, it was mainly the standard immunizations received in childhood. There was low vaccination uptake for diseases associated with occupational risks such as rabies. Moreover, there was low use of personal equipment (PPE) such as gloves, overcoats and surgery gowns. PPE was mostly cleaned with normal washing detergents without much disinfection.

Table 4 presents a summary of the biosecurity measures adopted by veterinary students when visiting farms and attending livestock to minimize and prevent the risk of introduction and transmission of diseases within and between farms. The results of Table 4 show that students had a low usage of protective clothing and equipment (PPE) and the use of clean medical equipment to prevent disease transmission associated with touching animals, fluids and tissues while undertaking practical lessons, farm visits and internships. The students had a low adoption rate of important ICPs such as disinfection of work boots aimed at the prevention of farm-farm and between-herd transmission of livestock diseases. The use of the same needles and examination gloves within a farm poses a risk as it can lead to within-herd disease transmission.

Table 5 presents a summary of the adoption of ICPs and biosecurity measures that students are trained to take as veterinarians are meant to take, to minimize occupational exposure to zoonoses in the course of their work. Students had the perception that it was important to use PPE for personal protection from zoonoses.

Table 6 presents a summary of the main sources of information that veterinary students use. The majority of students relied on a range

TABLE 2 Veterinary students' perceptions of zoonoses ($n = 154$).

What level of importance do you attribute to the following statements?	Extremely important [*n* (%)]	Very important [*n* (%)]	Moderately important [*n* (%)]	Slightly important [*n* (%)]	Not at all important [*n* (%)]
How important is collaboration between human and animal healthcare providers for ensuring public health?	101 (65.6%)	32 (20.8%)	12 (7.8%)	8 (5.2%)	1 (0.6%)
How important is monitoring and detecting zoonoses or outbreaks in animal populations for preventing human infection?	104 (67.5%)	34 (22.1%)	12 (7.8%)	4 (2.6%)	-
How important is maintaining ecosystem and environmental health for protecting human and animal health?	96 (62.3%)	37 (24.0%)	13 (8.4%)	8 (5.2%)	-
How important is preventing human encroachment in preventing the emergence of new human and animal diseases?	93 (60.4%)	40 (26.0%)	17 (11.0%)	3 (1.9%)	1 (0.6%)
How important is addressing climate change for preventing the emergence of new human and animal diseases?	94 (61.0%)	41 (26.6%)	11 (7.1%)	6 (3.9%)	2 (1.3%)

To what extent do you agree or disagree with the following statements?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Consumers of animal products are at risk of contracting zoonoses	43 (27.9%)	91 (59.1%)	8 (5.2%)	5 (3.2%)	7 (4.5%)
Animals can serve as disease sentinels for human health	83 (53.9%)	46 (29.9%)	12 (7.8%)	4 (2.6%)	9 (5.8%)
Climate change, directly and indirectly, impacts human and animal health	47 (30.5%)	85 (55.2%)	12 (7.8%)	3 (1.9%)	7 (4.5%)
Veterinary and animal health professionals are at risk of contracting zoonoses	42 (27.3%)	90 (58.4%)	11 (7.1%)	2 (1.3%)	9 (5.8%)
Farmers and farm-workers are exposed to the risk of contracting zoonoses	57 (37.0%)	74 (48.1%)	13 (8.4%)	2 (1.3%)	8 (5.2%)

of sources to get information on zoonoses, ICPs, biosecurity measures, One-Health, antibiotic resistance, new emerging treatments, and animal disease outbreaks. There is a strong reliance on personal networks such as peers and colleagues. There is also a reliance on online sources to source information regarding new treatments, disease emergence and new emerging technologies.

Table 7 presents a summary of the ease of accessing information on various topics and from different sources. Students perceived that it was not easy to access information on antibiotic resistance, new treatments, and animal disease outbreaks. Access to information from other sources was perceived as easy, particularly from training curriculum, peers (colleagues and friends), mass media (TV, Radio newspaper), and online searches such as Google and social media (Facebook, Twitter, Instagram, LinkedIn).

Discussion

This study explored students' perception of zoonoses risks; understanding of ICPs and biosecurity measures; disposal of medical waste materials; uptake of vaccines; and access to information that could reduce the occupational risk associated with exposure to zoonotic diseases. Globally, discussions are ongoing among veterinary medicine educators and administrators regarding the need to update 'traditional' veterinary curricula to address public health challenges faced at local, national and international levels, from the emergence of new zoonotic diseases to the re-emergence of endemic zoonoses, i.e., Rift Valley fever, SARS, pandemic influenza H1N1 2009, Yellow fever, Avian Influenza (H5N1) and (H7N9), West Nile virus, and Middle East Respiratory Syndrome coronavirus (MERS-CoV) (27). These discussions reflect a growing recognition that farmers' ability to realize desirable animal health and productivity outcomes, as well as human and environmental health outcomes, is contingent on their access to quality services provided by well-trained and skilled veterinary and animal health professionals (28). Veterinary students' ability to grasp and recall knowledge, for example, regarding zoonotic disease risks and antibiotic stewardship; make rational decisions; and communicate effectively with farmers directly impacts their ability to transition from an educational setting to a public or private practice setting (29). As students' knowledge and skills base are shaped, in part, by the veterinary education curricula followed, the results of this study underscore that there is a need to better align veterinary training with emerging global trends, such as One Health-focused training that fosters collaborative transdisciplinary and interdisciplinary thinking to realize animal, human, and environment health (30–32).

Perceptions of zoonoses risk among veterinary students at Ethiopian universities

The results of this study suggest that only a minority of students would rely on ICPs to prevent exposure to occupational zoonoses and recommend their use by farmers (Tables 3, 6). Previous research has shown that students face occupational exposure to zoonotic diseases due to their handling of live animals and/or their tissue (15, 26, 33). Practicing students could potentially disseminate zoonotic pathogens to their relatives or the animals they are treating during placements and internships, and thus the use of ICPs and hygienic measures is important to prevent disease spread (34). Veterinarians typically have higher seroprevalence for zoonoses

TABLE 3 Infection control practices (ICPs) and biosecurity measures adopted by veterinary students for disease prevention ($n = 154$).

		n (%)
How do you clean and take care of your reusable material and equipment (needles, syringes, scalpels, razors)?	Cleaning with detergent only	94 (61.0%)
	Cleaning with detergent and soaking in disinfectant	35 (22.7%)
	Cleaning and autoclaving (hot sterilization)	25 (16.2%)
How often do you wash your hands while working with animals?	After each animal	64 (41.6%)
	After each lot	56 (36.4%)
	After each cattle farm	33 (21.4%)
	No regular cleaning	1 (0.6%)
How do you wash or clean your hands after working with animals?	Clean with water only	122 (79.2%)
	With a soap	146 (94.8%)
	With an antibacterial soap	113 (73.4%)
	With hand sanitizer	80 (51.9%)
How do you dry your hands?	With re-usable towel	38 (24.7%)
	With a paper towel	115 (74.7%)
	Other (please specify) air drying	1 (0.6%)
Do you carry a yellow container for medical waste when you visit farms (i.e., in your car or bag)		133 (86.4%)
How do you dispose of empty medicine packaging and vaccine flasks/vials?	Yellow container for medical waste in the lab	127 (82.5%)
	Domestic trash can	129 (83.8%)
	Collected by a specialized company	132 (85.7%)
	Glass waste container	132 (85.7%)
	Government waste place	67 (43.5%)
Have you been vaccinated for zoonotic and other likely occupational diseases?	Yes, I have been vaccinated	132 (85.7%)
	Yes, for Tuberculosis	4 (2.6%)
	Yes, for Tetanus	10 (6.5%)
	Yes, for Rabies	19 (12.3%)
How often do you change your overall, apron or overcoat?	I wear reusable clothing and change it as soon as it is visually dirty	32 (20.8%)
	I wear reusable clothing and change it after specific 'dirty' work	55 (35.7%)
	I wear reusable clothing and change it after every cattle farm	32 (20.8%)
	I wear reusable clothing and change it every day	29 (18.8%)
	I use a set of disposable clothing for each cattle farm	2 (1.3%)
	I use disposable clothing (i.e., different set per cattle herd/group)	1 (0.6%)
	I use clothing provided by the farmer	3 (1.9%)
When performing surgeries, what do you wear?	Disposable calving gowns	15 (9.7%)
	Washable calving gowns under ordinary circumstances, but disposable gowns in case of known septic risk	98 (63.6%)
	A washable gown used of calving (calving gowns)	41 (26.6%)
What do you use when washing your work clothes and linen?	Detergent	56 (36.4%)
	Disinfectant	104 (67.5%)
	Soap	147 (95.5%)
	Coldwater	122 (79.2%)
	Warm water	50 (32.5%)
	Hot water	11 (7.1%)

than the general population due to their occupational exposure (3, 34). The results of this study affirm that it is important to ensure proper training of students on occupational risks related to zoonoses exposure in day-to-day activities, as has previously been suggested in the literature (3, 6, 15).

Veterinary students' understanding of ICPs and biosecurity measures

The findings of this study suggest a low perception of the importance of biosecurity measures adoption among students. This

TABLE 4 Biosecurity measures that veterinary students would adopt when working on farms ($n = 154$).

	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
How would you take care of your work boots?	After each farm	Before each farm	After and before each farm	Between two buildings on the same farm	Only when they are visually dirty	Never
Brushing	14 (9.1%)	12 (7.8%)	27 (17.5%)	81 (52.6%)	20 (13.0%)	0
Use of water jet (if provided at the farm)	3 (1.9%)	9 (5.8%)	35 (22.7%)	83 (53.9%)	18 (11.7%)	6 (3.9%)
Cleaning with soap	9 (5.8%)	5 (3.2%)	39 (25.3%)	55 (35.7%)	43 (27.9%)	3 (1.9%)
Disinfection	7 (4.5%)	9 (5.8%)	48 (31.2%)	25 (16.2%)	63 (40.9%)	2 (1.3%)
Stepping through foot bath or stepping on the foot mat (if provided at the farm)	2 (1.3%)	8 (5.2%)	34 (22.1%)	54 (35.1%)	47 (30.5%)	9 (5.8%)

How often do you replace the following disposable materials and equipment?	After each animal	After each herd	After each farm	Every day	Less frequently than every day
Needles for injections	26 (16.9%)	17 (11.0%)	21 (13.6%)	89 (57.8%)	1 (0.6%)
Sample collection needles	16 (10.4%)	15 (9.7%)	20 (13.0%)	103 (66.9%)	–
Syringes for injections	17 (11.0%)	11 (7.1%)	17 (11.0%)	102 (66.2%)	7 (4.5%)
Scalpel and razor blades	19 (12.3%)	9 (5.8%)	29 (18.8%)	83 (53.9%)	14 (9.1%)
Examination gloves	14 (9.1%)	13 (8.4%)	46 (29.9%)	59 (38.3%)	22 (14.3%)
Full-arm veterinary gloves	12 (7.8%)	13 (8.4%)	52 (33.8%)	48 (31.2%)	29 (18.8%)

TABLE 5 Infection control practices (ICPs) and biosecurity measures that veterinary students perform to minimize occupational exposure to disease when working on farms ($n = 154$).

In each of the following scenarios, please indicate the ICPs you would implement in examining animals and performing procedures.	Hand wash after contact	Gloves only	Boots/shoe disinfection	Overalls only	Gloves and overalls	Gloves, overalls, respiratory masks, and goggles	Not sure
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Post-mortem examination of a cow	24 (15.6%)	7 (4.5%)	2 (1.3%)	5 (3.2%)	12 (7.8%)	103 (66.9%)	1 (0.6%)
Routine examination of a cow	13 (8.4%)	17 (11.0%)	2 (1.3%)	7 (4.5%)	12 (7.8%)	103 (66.9%)	–
Cow with acute watery diarrhoea	11 (7.1%)	11 (7.1%)	10 (6.5%)	7 (4.5%)	10 (6.5%)	103 (66.9%)	2 (1.3%)
Aborted fetal material from a cow	4 (2.6%)	11 (7.1%)	7 (4.5%)	11 (7.1%)	27 (17.5%)	91 (59.1%)	3 (1.9%)
Cow with dystocia (calving problems)	3 (1.9%)	11 (7.1%)	8 (5.2%)	15 (9.7%)	57 (37.0%)	46 (29.9%)	14 (9.1%)
An animal with a multidrug-resistant urinary tract infection (after a number of treatments with different drugs)	46 (29.9)	3 (2.0)	57 (37.0)	15 (9.7)	11 (7.1)	8 (5.2)	14 (9.1)
Entering a farm	48 (31.2)	5 (3.3)	47 (30.1)	16 (10.4)	4 (2.6)	13 (8.4)	21 (13.6)

is concerning from an occupational safety and public health perspective given that biosecurity-related behavior can prevent disease transmission (5–7). Jackson and Villarroel (2012) observed that most veterinarians suffer from a zoonotic disease early in their careers, or even during their time spent at veterinary school. Training can prepare veterinary students for occupational risks associated with exposure to zoonoses in their day-to-day lives and incentivize their adoption of ICPs which reduce and prevent zoonoses risks (6, 15, 26). Studies suggest that training on critical biosecurity strategies, such as sanitation and disinfection procedures, as well as visitor and workflow policies, are key to disease prevention and control strategies (3). The results of this study affirm that, in the context of zoonoses prevention, the importance of using PPE, being vaccinated, and implementing ICPs should be emphasized in the training of veterinary students (26). Veterinarian students' attitudes towards personal protection as practicing veterinarians can be changed or improved and rendered sustainable over time by the veterinary curricula followed (6, 15, 28, 34). As veterinarians are role models for farmers, veterinary students' behavior based on knowledge and skills derived in an educational setting also has

TABLE 6 Main sources of information for veterinary students ($n = 154$).

	Education curriculum	Colleagues and friends	Mass media (TV, Radio, newspaper)	Scientific journals	Online searches (i.e., Google)	Social networks (i.e., Facebook, Twitter, Instagram, LinkedIn)	Government communication	Professional association and subscriptions
Zoonoses	24 (15.6%)	64 (41.6%)	96 (62.3%)	98 (63.6%)	105 (68.2%)	98 (63.6%)	49 (31.8%)	12 (7.8%)
Biosecurity measures and/or ICPs	27 (17.5%)	59 (38.3%)	86 (55.8%)	107 (69.5%)	104 (67.5%)	103 (66.9%)	53 (34.4%)	18 (11.7%)
One-Health	24 (15.6%)	54 (35.1%)	91 (59.1%)	100 (64.9%)	104 (67.5%)	95 (61.7%)	52 (33.8%)	20 (13.0%)
Antibiotic resistance	29 (18.8%)	57 (37.0%)	108 (70.1%)	106 (68.8%)	111 (72.1%)	92 (59.7%)	51 (33.1%)	18 (11.7%)
New treatments	20 (13.0%)	58 (37.7%)	99 (64.3%)	97 (63.0%)	104 (67.5%)	84 (54.5%)	42 (27.3%)	17 (11.0%)
Animal disease outbreaks	25 (16.2%)	64 (41.6%)	97 (63.0%)	98 (63.6%)	100 (64.9%)	100 (64.9%)	60 (39.0%)	13 (8.4%)

implications for farmers' adoption of ICPs and biosecurity measures (35, 36).

The findings of this study indicate a low perception among veterinary students of the importance of implementing biosecurity measures when visiting farms and attending to livestock. Students' behavior may increase the risk of the transmission of zoonotic diseases within and between farms (3). To minimize and prevent such risks at farms, it is crucial to ensure that visitors, including veterinary students, adopt biosecurity measures and use PPE when visiting farms and attending livestock (3, 6, 15). Biosecurity measures, such as the use of PPE and disinfection of work boots, have been recommended for the control of within- and between-herd transmission of zoonoses (23, 37). Although it can be expensive to use different PPE equipment for each animal, there is a need to ensure medical equipment such as syringes, needles and gloves are disinfected properly after use for each animal to minimize the risk of disease transmission within and between herds (23, 37).

Disposal of medical waste materials

The results of this study suggest that students were aware of the zoonoses transmission risks associated with handling medical waste. The findings also highlight the need to train students on the proper disposal of medical waste materials, such as needles, razor blades and animal tissue, to avoid environmental contamination (38). Environmental contamination can serve as a reservoir for pathogens and can expose humans and animals to zoonotic diseases.

Veterinary students' access to information regarding zoonoses

The findings of this study reveal that veterinary students acquired information from various sources beyond the training veterinary curriculum followed, including peers (colleagues and friends), mass media (TV, Radio newspaper), online search engines (Google) and social networks (Facebook, Twitter, Instagram, LinkedIn). These information sources enable veterinary students to easily access and triangulate information which facilitates their decision making. Increased access to the internet and mobile phones and the emergence of online learning platforms have enabled students to accumulate knowledge beyond that which is taught in a classroom setting. It is, however, concerning that veterinary students believed that it was not easy to access information on antimicrobial resistance (AMR), new treatments and animal disease outbreaks, given the importance of these topics in Ethiopia and beyond (16, 18, 23). AMR results in therapeutic failures and increases lengths and/or cycles of treatment which has negative downstream impacts on animal welfare, food security, and public health (39). Access to information on animal disease outbreaks is crucial to managing and containing outbreaks and safeguarding animal, human and environmental health and livelihoods (19, 20). Ensuring that veterinarians and veterinary students have access to information on new treatments available in the market is key to enabling them to make informed decisions on treatments and prescriptions (19, 25).

TABLE 7 The ease of accessing information sources ($n = 154$).

How easy is it to get information on the following topics?	Very easy	Easy	Moderately easy	Difficult
	n (%)	*n* (%)	*n* (%)	*n* (%)
Zoonoses	42 (27.3%)	55 (35.7%)	50 (32.5%)	7 (4.5%)
Personal ICPs	18 (11.7%)	74 (48.1%)	55 (35.7%)	7 (4.5%)
Farm biosecurity measures	20 (13.0%)	74 (48.1%)	49 (31.8%)	11 (7.1%)
One-Health	14 (9.1%)	71 (46.1%)	56 (36.4%)	13 (8.4%)
Antibiotic resistance	16 (10.4%)	57 (37.0%)	67 (43.5%)	14 (9.1%)
New treatments	20 (13.0%)	41 (26.6%)	76 (49.4%)	17 (11.0%)
Animal disease outbreaks	27 (17.5%)	32 (20.8%)	68 (44.2%)	27 (17.5%)
How easy is it to get information from the following sources?	**Very easy**	**Easy**	**Moderately easy**	**Difficult**
Training Curriculum	19 (12.3%)	61 (39.6%)	63 (40.9%)	11 (7.1%)
Colleagues and friends	20 (13.0%)	78 (50.6%)	49 (31.8%)	7 (4.5%)
Mass media (TV, Radio newspaper)	27 (17.5%)	62 (40.3%)	54 (35.1%)	11 (7.1%)
Scientific journals	27 (17.5%)	56 (36.4%)	63 (40.9%)	8 (5.2%)
Online searches, e.g., google	41 (26.6%)	50 (32.5%)	56 (36.4%)	7 (4.5%)
Social media (Facebook, Twitter, Instagram, LinkedIn)	37 (24.0%)	55 (35.7%)	55 (35.7%)	7 (4.5%)
Government communication	21 (13.6%)	64 (41.6%)	57 (37.0%)	12 (7.8%)
Professional association and subscriptions	15 (9.7%)	71 (46.1%)	55 (35.7%)	13 (8.4%)

Policy implications

This study highlights the imperative for veterinary medicine educators to include material on zoonotic disease risks in their veterinary science degree programs, particularly focusing on biosecurity measures (i.e., hygienic measures and the use of ICPs) as a way of developing a culture that prevents occupational exposure during training and, later, in practice. In line with global initiatives, there is a need for One Health-focused training that fosters collaborative efforts of multiple disciplines working locally, nationally and globally to improve health human, animal and environmental health (30). Given the impact of zoonoses on livestock and humans, there is a need to bridge human health and animal health education and training systems (40). Students in Ethiopia could benefit from being informed about and engaging with the principles of One Health in the context of their university and college-level education and subsequent professional training, as recommended by the American Veterinary Medical Association (30). Currently, the Africa One Health University Network (AFROHUN), the International Livestock Research Institute (ILRI), and the One Health Research, Education and Outreach Centre in Africa (OHRECA) project are working to transform the training environment and approaches in African universities and capacity building through collaborative curriculum design and peer-peer benchmarking (31, 32).

The education that veterinary students receive should ensure that they are well-prepared for the job market (28). The results of this study show that there is a need to ensure that veterinary students receive holistic training that encompasses (i) laboratory diagnostics skills; (ii) practical skills that enable them to identify and respond to AMR and treat livestock diseases; and (iii) clinical skills required to practice reproductive and preventive medicine. The emergence of antimicrobial resistance is driven by the overuse of antimicrobials in human and/or veterinary medicine (41). Implementing One Health training through interdisciplinary training in the form of practical workshops, in-practice training, and external training with practitioners from other related disciplines can ensure veterinary students are equipped to respond to emerging health challenges such as AMR and new emerging zoonoses (28, 30). One Health can enable collaboration and exchange of information among human, animal and environmental health practitioners and could facilitate sharing of scares resources such as laboratories and laboratory expertise (40, 42). Realizing One Health and interdisciplinary training in veterinary schools hinges on the allocation of adequate resources and support by relevant public and private veterinary sector stakeholders (17, 28).

Study limitation

In this study, we did not have the exact number of students enrolled in Ethiopian universities. We relied on convenience and purpose sampling to reach as many students as we could taking into account the travel restrictions related to COVID-19 that were present at the time that this research was conducted. An online questionnaire enables participants to answer questions at a time that is convenient and takes as much time as needed to respond. Online questionnaires render participation research more accessible to individuals with the internet or electronic devices such as phones and/or computers. Although the main objective of this sampling approach was to draw a diverse sample from across the population of university and college students in Ethiopia, a self-selection bias led to the majority of

respondents being from the major universities in large cities where students tended to have a strong online presence and were active on social networks.

Conclusion

The findings of this study suggest that there are currently gaps that need to be bridged in the teaching of veterinary students in Ethiopia, particularly related to the use of ICPs and biosecurity measures and the extent to which the 'traditional' veterinary education curricula could and should be improved to address public health challenges faced at local, national and international levels, from the emergence of new zoonotic diseases to the re-emergence of endemic zoonoses. Curriculum standardization and capacity training in line with the One Health concept could contribute to enhancing veterinary students' access to information regarding infection control practices and biosecurity measures could contribute to reducing their future occupational exposure to zoonoses. Increasing the availability of personal protection equipment, such as gloves, could also increase the likelihood that students are in a position to engage in practical training and gain knowledge and skills beyond the realm of the theoretical education received. This study makes an important contribution to the literature on veterinary students' knowledge of zoonotic diseases of public health importance and the source of this knowledge, as well as their preparedness to respond to these diseases, in the Global South. The findings of this study suggest that universities and colleges play an important role in equipping students with the skills and knowledge that enable them to make informed decisions on treatments and prescriptions and prevent within and between herd transmission of zoonotic infection. Against a backdrop of the emergence of new zoonotic diseases and the re-emergence of endemic zoonoses, it can be expected universities and colleges will continue to constitute a critical link in the translation of veterinary knowledge into practice, with veterinary medicine educators through their delivery of an updated education curriculum ensuring that veterinary students are in a position, in their subsequent careers as veterinarians and animal health practitioners, to effectively address the public health risks posed by zoonoses and enhance animal, human, and environmental health.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

NN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. LP: Formal analysis, Methodology, Visualization, Writing – review & editing. JL: Supervision, Visualization, Writing – review & editing. SB: Funding acquisition, Supervision, Writing – review & editing. EM: Formal analysis, Visualization, Writing – review & editing. AM: Funding acquisition, Methodology, Supervision, Writing – review & editing. JW: Funding acquisition, Methodology, Supervision, Writing – review & editing. HM: Funding acquisition, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2024.1385849/full#supplementary-material

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Voluntary optimisation of antimicrobial consumption in swine and poultry production in Thailand: a policy analysis

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Antimicrobial resistance (AMR) is a global health concern with significant implications on economies and health security, affecting humans, animals, food, and the environment. To tackle this issue, promoting responsible antimicrobial use in livestock production has emerged as a crucial intervention. In 2018, Thailand introduced the Voluntary Optimization of Antimicrobial Consumption (VOAC) programme, with the objective to encourage responsible antimicrobial use practises. This study aimed to analyse the context, content, process and actors of the VOAC programme. A qualitative method including document reviews and key informant interviews were applied. In-depth interviews were conducted with 18 key informants who are key stakeholders from public and private sectors involved in the policy formulation, design of policy contents and implementation of VOAC: policy makers or officers responsible for animal health ($n = 12$), animal producers ($n = 2$), animal product traders or retailers ($n = 2$), and farm veterinarians ($n = 2$). Interview transcripts were validated by informants for accuracy, and triangulated with document review findings. Deductive approach was applied for data analysis and interpretation based on Walt and Gilson's policy analysis framework. The VOAC farm certification comprises of Raised Without Antibiotics (RWA) and Reducing Antibiotic Use (RAU), both aiming to combat AMR in food animals. Global and national factors, including increased public awareness, policy commitments, export requirements from the European Union, and international organisation advocacies, influenced the development of the programme led by the Department of Livestock Development (DLD), under the Ministry of Agriculture and Cooperatives. Collaboration with the private sector facilitated policy clarity, with implementation primarily executed through regional, provincial, and district livestock officers. Integration of the programme with the pre-existing Good Agriculture Practise certification system enabled cost-effective implementation without additional resources. In 2022, DLD official data reported 214 RWA farms (112 pig and 102 broiler), and 230 RAU farms (83 pig and 147 broiler). Incentives for farms to participate in the programme include improving corporate image and demonstrating corporate responsibility addressing AMR in food products. Recommendations include optimising certification strategies, increasing consumer awareness of RWA and RAU products and strengthening monitoring and evaluation systems.

KEYWORDS

antimicrobial resistance, poultry, pig, antimicrobial, antibiotic, policy, policy analysis

Introduction

Antimicrobial resistance (AMR) is one of the most critical health concerns, threatening economies and health security worldwide (1). AMR is a One Health issue as it can spread across humans, animals, food, and the environment. In particular, resistant bacteria can be transmitted from animals to humans through the consumption of animal products contaminated with antimicrobial resistant bacteria, by direct contact or indirectly through the environment (2).

One of the main selective pressures of antimicrobial resistant bacteria in food producing animals is antimicrobial use (AMU), a common practise to treat, control and prevent diseases (3). Hence, it is essential to reduce AMU or improve prudent use in animal food production globally, as called upon in the Food and Agriculture Organisation (FAO) Action Plan on AMR (4) and World Organisation for Animal Health (WOAH) Strategy on AMR and the Prudent Use of Antimicrobials (5), which are aligned with the Global Action Plan on Antimicrobial Resistance (GAP-AMR) (6). A systematic review and meta-analysis showed that interventions which restrict antibiotic use in food-producing animals are associated with a reduction in the presence of antibiotic-resistant bacteria in these animals (7). On top of regulations of antimicrobial distribution and use, many activities have been proposed to optimise AMU in animal health. For example, the European Medicine Agency (EMA) and the European Food Safety Authority (EFSA) suggested measures along the three principles 'reduce, replace and rethink'. These measures include setting national goals for reducing antimicrobial consumption, eliminating unnecessary use by replacing them with alternative measures such as vaccines, reserving critically important antimicrobials for humans as the last choice, and rethinking livestock production systems through implementation of farming practises such as proper sanitation and biosecurity to prevent infection (8, 9).

In Thailand, AMR has been a top priority, demonstrated by the Cabinet endorsement of the National Strategic Plan on Antimicrobial Resistance (NSP-AMR) 2017–2021 in 2016. The NSP-AMR aimed to achieve a 30% reduction in antimicrobial consumption by 2021. Goal 3 of the NSP-AMR focused on promoting appropriate AMU with various interventions including prohibition of AMU for growth promotion in food animals, as well as surveillance and monitoring of AMR and AMU in livestock (10).

The swine and poultry sectors are vital components of Thailand's livestock industry (11). In 2022, the country produced 10.8 million pigs and 300.4 million broilers, which reflect the significant scale of livestock production (12). The livestock industry in Thailand accounted for 21.1% of the total value of agricultural exports in 2020 (12). The exported-oriented industries of broilers and swine products have to adhere to requirements by imported countries. For example, the Europen Union issues certain conditions, such as low levels of farm antibiotic use, below 30 mg per kg of population correction unit (PCU) by animal species, and most antibiotic use should be for individual treatments, and restrictions on highest-priority critically important antibiotics (13).

Goal 3 of the NSP-AMR has been achieved with 36% reduction, from 658.7 mg/$PCU_{Thailand}$ in 2017 to 421.5 mg/$PCU_{Thailand}$ in 2020 (14). One of the initiatives of Thailand to reduce AMU has been the development and implementation of Voluntary Optimization of Antimicrobial Consumption (VOAC) certification programme, mentioned in Strategy 4 of the NSP-AMR: Prevention and control of AMR and the optimal use of antibiotics in agriculture and animals. The DLD under the Ministry of Agriculture and Cooperatives took the lead in launching the VOAC programme in 2018, which includes two farm certifications: RWA and RAU. Under the RWA certification, the use of antibiotics from birth to harvest is strictly prohibited, while the RAU certifies farm that demonstrate a reduction in antibiotic use.

The aims of this study were to analyse the context, content, process and actors of the VOAC certification programme.

Materials and methods

Study context

Thailand, classified as an upper-middle-income country, features an agricultural sector that contributes approximately 8% to its GDP (15). In 2022, the country produced 10.8 million pigs by 149,575 farmers and 300.4 million broilers by 31,117 farmers, which reflect the significant scale of livestock production (12). Though there is no accurate and up-to-date records on number of poultry and swine farms by their annual production capacities, a few largest scale high technology conglomerate producers are the market leaders which occupied major market especially for exports due to their technologies and capital. However, the production capacity of small farm holders are limited and mostly for local markets.

To enhance farm management practises, the Thai Department of Livestock Development (DLD) awards Good Agriculture Practises (GAP) certificates to farms that adhere to stringent standards of animal husbandry. These certified farms are mandated to engage designated veterinarians to oversee disease control, prevention, and treatment, including the judicious use of antibiotics. While GAP certification remains voluntary, it serves as a testament to the commitment towards sustainable agricultural practises. Notably, in 2019, Thailand recorded a total antimicrobial consumption of 336.3 mg/PCU in food-producing animals (16). The National Strategic Plan on Antimicrobial Resistance (NSP-AMR) has been implemented from 2016 to 2021 reflects a proactive stance, exemplified by the complete prohibition of antimicrobial use as growth promoters since 2015. In 2018, most veterinary antimicrobials in Thailand were categorised as dangerous drugs, exempt from prescription requirements but necessitating dispensation by licenced pharmacists or veterinarians at authorised pharmacies (17).

Abbreviations: AFVC, Animal feed and veterinary products control; AMR, Antimicrobial resistance; ASF, African swine fever; DLD, Department of Livestock Development; EMA, European Medicine Agency; FAO, Food and Agriculture Organisation; FDA, Food and Drug Administration; GAP, Good Agricultural Practise; GAP-AMR, Global Action Plan on Antimicrobial Resistance; NSP-AMR, National Strategic Plan on Antimicrobial Resistance; NSF, National Sanitation Foundation; PCU, Population correction unit; PLO, Provincial Livestock Offices; PRRS, Porcine reproductive and respiratory syndrome; RWA, Raised without antibiotics; RAU, Reducing antibiotic use; VOAC, Voluntary optimisation of antimicrobial consumption; WOAH, World Organisation for Animal Health; WHO, World Health Organisation.

Study design

This study was carried out in Thailand from September 2021 to July 2022 by employing a qualitative approach. Reviews of relevant policies and regulations were followed by in-depth interviews with different level of stakeholders who involved in the programmes. Triangulation of interview findings was carried out by verifying with findings from document reviews. Qualitative research methods were utilised to explore and understand the policy processes of introducing and implementing the VOAC in the swine and poultry production. Such methods allowed researchers to delve into the perspectives, experiences, and behaviours of different stakeholders (including policy makers, implementers, and the industry) involved in antimicrobial use. Furthermore, employing a case study approach (18) enabled researchers to unpack and understand the complex issue in real life setting using the case of antimicrobial consumption in swine and poultry production in Thailand.

The policy analysis of the VOAC programme was carried out according to the framework developed by Walt and Gilson (19). This framework consists of four components: policy context, content, process and actors (Figure 1). The context component focused on understanding the environmental, social, and political factors that led to the adoption of the VOAC programme. This encompassed examining factors such as economic conditions, public opinion, scientific evidence, cultural considerations, and legal frameworks. The content of the policy was examined to gain insights into its objectives, scope, and specific provisions. The policy process was analysed in terms of agenda setting, policy formulation and policy implementation. Key actors involved in the policy process include individuals, organisations, and institutions that played various roles in policy development, decision-making, and implementation.

Data collection

To collect the necessary information related to policy analysis, a document review was carried out, followed by key informants interviews.

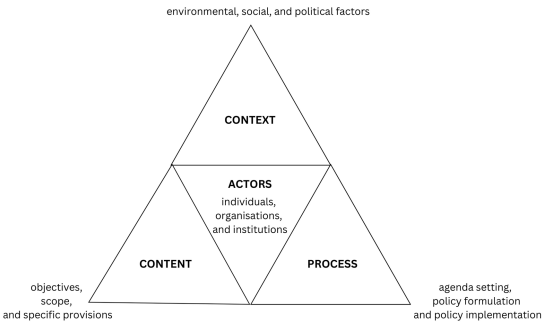

FIGURE 1
Policy analysis framework. Adapted from Walt and Gilson (19); with permission from Oxford University Press. Reforming the health sector in developing countries: the central role of policy analysis.

Document review

A thorough analysis of policy documents and related regulations was conducted. The review aimed to identify and examine policies concerning the VOAC in swine and poultry production settings. Key documents included the NSP-AMR covering the period from 2016 to 2021. Additionally, documents related to RWA and RAU certifications were retrieved and reviewed to provide a thorough understanding of the regulatory framework which governs antimicrobial use in the food animal production, as well as certification reports, programme reports, and other relevant materials.

Key informant interviews

The key informant interviews were conducted to obtain further information about the VOAC and its RWA and RAU certifications, especially regarding their implementation. A semi-structured interview guide was designed based on the policy analysis framework by Walt and Gilson (Supplementary material 1). The interviews were conducted in Thai through video conference and audio-recorded.

On average, each interview session lasted approximately one and a half hours. The interviews took place in a conducive environment mostly in the office of participants which ensured privacy and comfort for both the interviewers and respondents. In terms of ethical consideration, while written consent is considered best practise, logistical constraints during the interviews necessitated the use of verbal consent in this study. Participants were fully informed of their rights, including the right to withdraw from the study at any point and the right to request anonymity. Participants are provided with researchers' contact detials. Participants' contact information was requested and provided to support follow-up and clarification of the study's findings if needed.

A purposive sampling technique was utilised to select key informants from governmental organisations responsible for AMR policy at national and local levels including the Animal Feed and Veterinary Products Control (AFVC), Bureau of Quality Control and Livestock Product and Provincial Livestock Offices (PLO) from four purposive selected provinces. In addition, to diversify perspectives from stakeholders outside government sector, relevant private sector associations such as Animal Health Products Association (AHPA) and the Thai Feed Mill Association (TFMA), were requested to propose lists of their officers or members who could provide information about RWA and RAU certifications including animal product retailers and farm veterinarians. Furthermore, AFVC was consulted to propose names of livestock producers who participated the certifications. It should be noted that, in this study, we did not involve key informants from farms which are not in the VOAC programme.

In total, 18 key informants from the public and private sectors involved in the development and implementation of the VOAC programme were interviewed after verbal consent. They were categorised into four groups according to their respective roles (Table 1). Though we received the name and contact of eight farmers for both pig and poultry productions, only two of them agreed to be interviewed after contact and explanation about the study.

Data processing and analysis

Following the interviews, each key informant was requested to validate his/her transcription to ensure the accuracy of the information

TABLE 1 Four groups of respondents' profiles.

	Total (*N* = 18)	Gender		Age (average, range)
		Male (12)	Female (5)	
Group A: Policy makers or officers responsible for animal health	12	7	5	47 (34–61)
Group B: Animal producers or farmers	2	2	0	63 (55–71)
Group C: Animal product traders or retailers	2	2	0	55.5 (55–56)
Group D: Veterinarians (farm veterinarians)	2	2	0	59 (51–67)

provided. This was followed by a triangulation to cross-verify findings between interviews and document reviews. Subsequently, two teams of researchers, each comprises of two researchers (AL and SK1; SK2 and WK), independently analysed the collected data, after which they discussed the findings and reach a consensus. This ensures accuracy and consistency of interpretation between the two teams. A coding framework and pre-established codes developed by researchers provided a structured approach to categorise and analyse the data from document reviews and insights from key informant interview transcripts. The framework was structured in order to facilitate a deductive approach along the line of the policy process developed by Walt and Gilson. The policy process comprised of policy context, policy processes and policy contents. See details in Supplementary material 1.

Results

Our findings were organised under the policy process framework. Deductive approach was based on three major themes (a) Policy context with three subthemes: (i) regulatory framework, (ii) international regulatory compliance for accessing export markets, and (iii) NSF-initiated RWA certification; (b) Policy process including (b.1) agenda setting with two subthemes: (i) news and media attention: public awareness of AMR, (ii) global and national policies on the optimal use of antibiotics in animal production; (b.2) policy formulation with two subthemes: (i) government, private and academia collaboration, (ii) integration into NSP-AMR; (b.3) policy implementation with five subthemes: (i) role of the veterinary authority, (ii) agro-industrial participation, (iii) certification process and implementation, (iv) GAP certification integration and monitoring mechanisms, (v) implementation challenges; and (c) Policy content with two subthemes: (i) alignment with NSP-AMR goal, (ii) certification objectives and criteria. Stakeholder involved in the policy processes were discussed under relevant themes and subthemes. Table 2 summarised of theme and subthemes generatefrom this study.

Policy context

Thailand is a major livestock producer. It is also a major food exporter, ranked 15th globally and contributing to 2.3% of the total world food market (20). Since 2002, all Prime Ministers have declared that Thailand aims to be 'the Kitchen of the World', which reflects strong political commitment to exporting quality agricultural products (21).

In recent years, Thailand has enacted a number of regulations to support more prudent AMU in the animal sector. Since 2015, the use of all antimicrobials for growth promotion has been banned. Historically, the Thai Food and Drug Administration (FDA) classified most veterinary antimicrobials as 'dangerous drugs', which did not legally require a prescription though need to be dispensed by a licenced veterinarian or a pharmacist. Between 2019 and 2020, the FDA reclassified certain groups of antimicrobials, including cephalosporins, polymyxins (e.g., colistin), quinolones, and macrolides, as 'specially-controlled medicines'. This reclassification mandates that a prescription from a veterinarian is required for their dispension and use (22). Furthermore, DLD, under mandate of the Animal Feed Quality Control Act 2015, issued a notification in 2019 which mandates that dispensing and using medicated feed (i.e., feed mixed with medicines) requires a prescription (23). In addition, to address public health concerns, DLD also prohibited colistin and fluoroquinolones from mixing in animal feed in 2019, both of which are classified as highest priority critically important antimicrobials by the World Health Organisation (WHO) (24, 25).

In Thailand, the livestock production sector is predominantly controlled by large companies which apply vertical integration throughout the production-consumer chains (26). These companies are major producers of poultry and swine and own slaughterhouses and retail outlets for selling their products. Thailand is the world's largest exporter of frozen chicken, commanding a substantial 28.9% market share in terms of volume (27). Importing countries have established food safety regulations on meat products that exporters need to follow.

For example, the European Union set up the standard for food importer requirement; consumers also shape food quality and safety as is the case of EU Regulation 2018/848 (28). Paragraph 43 and its Annex II paragraph 1.5.1.3 and 1.5.1.4 which enforces export of organic products and labelling as organic products, shall not use antibiotics for preventive treatment and growth promotion.

RWA certification is an initiative by the National Sanitation Foundation (NSF) (29). The NSF develops standards for public health and certification programmes that help protect the quality of food, water, consumer products and environment. The DLD's RWA certification programme was introduced while the NSF was already providing the NSF RWA certification for Thai farms. Informants from RWA-certified producers informed us that although the DLD's RWA certification is not recognised by the EU, they still participate in the programme because they are already implementing RWA through the NSF.

Policy process

Agenda setting

Various factors shaped the VOAC agenda: public awareness of AMR, global and national policies on the optimal use of antibiotics in animal production, and demand from international consumers.

TABLE 2 Summary of theme based on policy analysis framework.

Themes based on policy analysis theme	Sub-themes
a. Policy context	i. Regulatory Framework ii. International regulatory compliance for accessing export markets iii. NSF-Initiated RWA certification
b. Policy process:	
b.1. Agenda setting	i. News and media attention: public awareness of AMR ii. Global and national policies on the optimal use of antibiotics in animal production
b.2. Policy formulation	i. Government-Private Sector-Academia collaboration ii. Integration into NSP-AMR
b.3. Policy implementation	i. Role of the veterinary authority ii. Agro-industrial participation iii. Certification Process and Implementation iv. GAP certification integration and monitoring mechanisms v. Implementation challenges
c. Policy content	i. Alignment with NSP-AMR goal ii. Certification objectives and criteria

News and media attention: public awareness of AMR

In 2016, there was widespread mass media attention on the presence of colistin resistant bacteria (carrying plasmid mediated *mcr-1* gene) in pigs in three provinces of Thailand, and the use of colistin in pig farms and human health consequences. Public concerns were raised about the possibility of AMR transmission from pigs to humans, leading to panic in the public about AMR in the food chain. The use of colistin, one of the reserved antibiotics, in pig farms was pointed out as the main driver for the presence of colistin resistant bacteria in pigs. Subsequently, the Minister of Public Health, the Secretary General of FDA and the Director General of DLD issued a press release confirming that FDA and DLD shall reclassify colistin for veterinary use from 'dangerous drugs' to 'specially-controlled medicines', which was finally accomplished in 2019.

Global and national policies on the optimal use of antibiotics in animal production

Several international policy documents, such as the GAP-AMR (8), the political declaration on AMR made at the United Nations General Assembly High-Level Meeting in 2016, the FAO Action Plan on AMR (4) and the WOAH Strategy on AMR and the Prudent Use of Antimicrobials (5), and the NSP-AMR recommend the optimal use of antibiotics in animal production. The NSP-AMR followed the 'One Health' approach which links various sectors and actors in defence of human, animal and environmental health (32).

All of the key informants from the private sector said their industry were aware of the GAP-AMR. A key informant from a private food-producing company informed that they have signed a commitment to support the United Nations efforts to combat AMR at the One Health Summit in 2016 (33).

> *'…In 2016, our company attended the One Health meeting and adopted five policies to jointly solve the problem of AMR such as responsible use of antibiotics under veterinary supervision, non-use of antibiotics for growth promotion, promoting raised animals without antibiotic and monitoring AMR at farms annually, in compliance with DLD. The company signed a commitment to support the United Nations efforts to combat AMR on October 16, 2017…'* [C01, male, age 55 years].

Policy formulation

The AFVC, at central level, is the key implementing agency for Strategy 4 of the NSP-AMR (AMR prevention and control and antimicrobial stewardship in agriculture and animals). Within this strategy, there is a sub-committee where members were representatives from the government, the private sector and academia. At a sub-committee meeting in 2017, the AFVC discussed the possibility of initiating the RWA and RAU certifications in Thailand.

In 2018, the RWA and RAU certifications were included in the operational plan of the NSP-AMR. On 30 April 2018, DLD signed the Memorandum of Understanding with livestock producers and food retailers for collaboration on RWA and RAU certifications on a voluntary basis. The AFVC set up the farm criteria in each certification, see Table 3.

Policy implementation

Department of Livestock Development serves as Thailand's national veterinary authority under which AFVC officers at national level are responsible for accrediting the RWA and RAU certifications. Staff at regional, provincial, and district levels serve as programme implementing bodies and monitor progress in addition to their routine activities such as animal health controls, veterinary public health controls and disease surveillance. Our document review identified at least five major agro-industrial livestock companies (livestock producers and retaliers) engaged in the RWA programmes, possibly driven by their existing certification as the NSF RWA

producers for exporting to EU member states. In 2022, DLD official data reported 214 RWA farms (112 pig and 102 broiler), and 230 RAU farms (83 pig and 147 broiler). The implementation processes for the VOAC programme involve several steps, including setting up an annual plan, application submission, inspection, certification, sample testing, and monitoring.

To establish the annual plan, the AFVC collaborates with regional, and PLO, to probe willingness of pig and poultry farms in their areas to voluntarily participate in the certification. The data collected by the PLO is compiled by the AFVC and included in the annual plan.

Livestock producers who hold GAP certification and wish to participat in either the RWA or RAU certifications can submit an application with the required documents to their PLO. The PLO reviews the application forms and relevant documents and conducts farm inspections to assess if the farms meet the certification criteria. Certificates are granted by the DLD to RWA and RAU farms. In the case of RAU farms, the provincial livestock offices monitor antibiotic use, antibiotic residue, animal health, and management practises on an annual basis.

The DLD applies the existing GAP certification system to facilitate the implementation of the RWA and RAU certifications. Since GAP farms already have designated veterinarians, these veterinarians are also involved in monitoring of RWA and RAU implementation related to the use of antibiotics. DLD auditors responsible for GAP certification, assigned to regional, provincial and district livestock offices, act as inspectors for RAW/RAU certification. Several areas are assessed, including health management and disease control, housing management, feed tracing to its source, water quality, and medicine usage.

In the course of inspections, samples are gathered for testing. Specifically, for the RWA programme, examinations include testing samples of animal feed and water for antibiotic presence. Additionally, meat product samples from both slaughterhouses and retailers undergo annual testing to detect antibiotic residues as part of the RWA certification. For the RAU certification, the farm veterinarian records antibiotic use and the auditor compares the use of antibiotics in the current cycle with the previous one using the mg/Population Correction Unit measurement during the annual inspection.

Samples collected are sent to regional livestock laboratory centres or laboratories owned by the Bureau of Quality Control of Livestock Products. The regional livestock office compiles the laboratory results and submits them to the AFVC. Based on the results, the AFVC issues one-year RWA certificates (renewable annually upon compliance to the requirement) or a three-year cerfication for RAU farms. The regional and provincial livestock offices are responsible for the overall field implementation.

> *'… I (a provincial livestock officer, author) provided information of the programme to farmers. When I received a number of farms that are willing to join, I submitted it to the regional livestock office, and then to AFVC…'* [A11, male, age 50 years].

> *'…AFVC discussed with regional and provincial livestock offices to review the previous plan and implementation, as well as a number of GAP certified farms in the region. Then, provincial livestock offices asked farms' willing to participation in their catchment area…'* [A07, male, age 47 years].

> *'… After compilation of data of participating farms, AFVC sent a number of farms to the provincial livestock office and then the provincial livestock office to implement in accordance with the rules and regulations of the project…'* [A04, male, age 57 years].

In some areas, there was a meeting among AFVC (central level), regional, provincial and district livestock offices to review the implementation progress and challenges.

The DLD will also grant RWA logo to farmers to advertise their RWA products and certificate for farmers.

> *'…RWA and RAU are policies that everyone would like to participate… participating the programmes has no additional cost to farmers. Government supported everything including the laboratory testing and provided them the certificate. It helped the farmers increase the products' price and market…'* [A10, male, age 36 years]

The implementation costs of the RWA and RAU certifications were covered by the DLD regular budget and no additional staff was recruited for this purpose. These certifications were integrated into the existing GAP certification system.

The RWA and RAU certifications were established to support the GAP-AMR and NSP-AMR implementation, especially to achieve the target set out by Goal 3, to reduce antimicrobial consumption in animals by 30% by 2021. However, a key informant from a PLO reported that he had never heard about the GAP-AMR or the NSP-AMR. On the other hand, a key informant from another PLO correctly described the target of the NSP-AMR of 30% reduction in antimicrobial consumption in animals. None of the key informants could provide specific details on how the monitoring or evaluation of the RWA and RAU certifications would be conducted.

> *'… I've never heard about the plan on AMR before. Is it the national plan or policy of the Ministry of Agriculture and Cooperative or DLD?…'* [A04, male, age 57 years].

> *'…We have no data on how the farms contribute to the reduction on antibiotic use in the country. It must be the central authority's work'* [A09, male, age 45 years].

Policy content

The policy content is aligned with the goals of the NSP-AMR, by aiming to control, prevent, reduce or slow down the emergence of AMR in animals. The RWA and RAU certifications intend to contribute to this objective by reduce AMU in food production. Indeed, the RWA certification strictly prohibits the use of antibiotics at any stage of the production cycle, while the RAU certification allows for the use of antibiotics, but certified farmers need to demonstrate a reduction in antimicrobial use. Table 3 summarises the objectives and requirements of the two certifications.

Discussion

The policy analysis of voluntary RWA and RAU programmes in swine and poultry production yields several insights for national and international audiences. The adoption of VOAC involves

TABLE 3 Comparison of objectives and requirements of the RWA and RAU certifications.

	RWA	RAU
Objectives	1. To control, prevent, reduce or slow down the problem of AMR in animals 2. To create animal producers' awareness on antibiotic-free animal production 3. To build consumer's confidence in food safety in antibiotic-free livestock products 4. To provide consumers choices of antibiotic-free livestock products	1. To control, prevent, reduce or slow down the problem of AMR in animals 2. To create animal producers' awareness on antibiotic reduction in animal production 3. To build consumer's choices of livestock products with rational use of antibiotics
Criteria	1. Health supervision by farm veterinarian (Farms with GAP certification* for pig fattening farm, it must receive β-Agonist free certification from DLD.) 2. No antibiotic use in any form at any stage of animal production 3. Water for animals without antibiotic contamination 4. Sick animals are treated by antibiotic and isolated outside the system/ farm. 5. Anticoccidials, vaccine or alternatives to antibiotics which are registered can be used. 6. Documents for traceability are kept and ready for inspection. 7. Samples including water, feed and products must be tested annually for antibiotic contamination.	1. Health supervision by farm veterinarian 2. Volume of antibiotic use must be reduced (compare between previous and current production cycle) 3. Documents for traceability are kept and ready for inspection

*The GAP certificate for pig farms was introduced as a voluntary standard for food safety to fulfil trade and government regulatory requirements. The National Bureau of Agricultural Commodity and Food Standards is the accreditation body, while the DLD provides implementation functions. Farmers submit their application form and relevant documents to their provincial livestock office which carries out the approval and an annual inspection. The standards range from farm infrastructure, animal feed quality, water quality, farm management, animal welfare, the environment, and animal health management including the use of antibiotics under veterinary supervision.

collaborations between the DLD and the private sector. The programmes are implemented by national, regional, and provincial livestock offices, but the monitoring and evaluation of the programme to address challenges remains unclear.

The commitments of provincial livestock officers to encouraging farmer participation and to annual monitoring of farms and slaughterhouses were identified as a key success factors. The adoption of VOAC was shaped by requirements by countries which are food importer such as European Union; consumers demand quality and safe food as is the case of EU regulation. In 2022, official data from the DLD indicated the presence of 214 RWA farms, consisting of 112 pig farms and 102 broiler farms. Additionally, there were 230 RAU farms, comprising 83 pig farms and 147 broiler farms. Statistics from DLD does not provide geographical location, the annual production capacity of each broiler or swine farm participated in RWA and RAU.

The challenges with labels featuring animal raising claims like RWA, such as consumer confusion, lack of universally accepted definitions, and credibility issues with voluntary, process-based label claims in general, are underscored by instances such as the removal of Tyson's label claims by the U.S. Department of Agriculture (35). This is particularly relevant given the participation of large agro-industrial conglomerates in the RWA and RAU programmes, which adopt a vertically integrated approach encompassing various stages of livestock production. Despite the potential benefits, such as positive corporate image and brand reputation, promotional efforts in Thailand face hurdles due to limited awareness among consumers about the RWA-DLD programme and antibiotic-free products, attributed to inadequate policy communication by DLD. Consequently, only select companies opt to display the NSF-certified RWA logo on their products.

The publicly available data on total sales and margins of premium products resulting from these programmes, compared to conventional production methods, is currently unavailable. Increased consumer demand for food safety and willingness to pay for premium prices can serve as an incentive for producers and retailers to participate in the programme. Besides international standards like the NSF, other private food standards are gaining significant attentions in other countries, for example large United Kingdom supermarket chains setting contractual standards for livestock producers and prohibiting routine preventive antibiotic use (36).

A Swiss study reveals that the willingness of dairy and veal calf fattening farms to voluntarily reduce or ban antibiotics is influenced by factors such as extra compensation and additional investments (37). Our study lacks concrete data on economic benefits for farmers participating in VOAC, such as cost savings from reduced AMU and potential premium prices for animal products through RWA and RAU. Moreover, some key informants were hesitant to disclose financial information, including cost savings associated with reduced antibiotic use, improvements in feed conversion ratios, or reductions in animal mortality rates in the programmes. While Thailand VOAC and Swiss study share similar objectives of reducing or ban use of antibiotic, our study did not have robust evidence and transparency regarding economic benefits.

The participation criteria for both RWA and RAU programmes include obtaining GAP certification, which requires having a designated farm veterinarian responsible for overseeing antimicrobial use. Consequently, farms lacking GAP certification were deemed ineligible for participation in these programmes. Such stringent requirement rendered the programmes inaccessible for small-scale farms grappling with financial constraints, presenting a notable barrier to their involvement.

Between 2020 and 2022, Thailand faced significant challenges due to the outbreak of Porcine Reproductive and Respiratory Syndrome (PRRS) and African Swine Fever (ASF). In response, certain RWA farms found it necessary to reintroduce antibiotics to manage secondary bacterial infections. This circumstance had a negative impact on the number of pig farms engaged in the RWA certification, contributing to a noticeable decrease. These fluctuations underscore the dynamic challenges from disease outbreaks and potential fragile bio-safety standards among farms.

Our in-depth analysis indicates that the RWA and RAU certifications played, at most, a minimal role in the overall antimicrobial consumption, supported by the limited enrollment of

farms, a majority of which were already the NSF RWA certified. However, despite its limited effectiveness, these certifications offer positive aspects of the certification. The RAU certification has potential for scaling up with a higher impact if its challenges are fully addressed and if outcomes such as cost savings from reduced antimicrobial use, increased productivity, changes in mortality rates, and economic gains are thoroughly analysed and disclosed. Given the current deficient statistics from DLD regarding the VOAC programme, it is challenging to attribute the RWA and RAU certifications alone to the achievement of the national goal of a 30% reduction in antimicrobial consumption from 2017 to 2021. However, there has been an overall national level reduction in antimicrobial consumption in food-producing animals from 658.7 in 2017 to 421.5 mg/$PCU_{Thailand}$ in 2020 (a 36% reduction) (38). Further, lack of consumer awareness campaign to recognise for DLD RWA logo for poultry and swine products, while widespread presence of the NSF RWA logo in the market, may contribute to the lack of incentives for more farms to participate in the VOAC programme. Furthermore, there is no monitoring of the market size of RWA and RAU products, which could potentially limit further advocacy efforts. Recognising consumer preferences as potential game-changers is essential, with studies indicating a willingness to pay higher prices for antibiotic-free products in the United States (39) and Europe (40). Focusing on scaling up consumer awareness in Thailand is pivotal, especially considering the limited awareness highlighted by the 2021 Health and Welfare Survey, only 22% of Thai households were aware about RWA products (41).

Limitations of the study

One key limitation of this study revolves around the representativeness of viewpoints and experiences among informants, especially farmers involved in the VOAC, which may affect the validity of the findings. Specifically, our study only included interviews with two farm managers from large scale production industries. Their view may be positively biassed towards the VOAC implementation feasibility, given their access to advance technologies, large capacity and resources, particularly in terms of farm bio-security, hygiene and sanitation which are enabling factors of low level of mortality when antibiotics were not used. Additionally, the limited farm-specific context provided by the two key informants such as animal health management limits the deep insights of programme implementation.

Moreover, the study's scope is constrained by the exclusive participation of only two animal producers actively engaged in RWA and RAU certifications. Despite efforts to enlist more farmer informants, reluctance to participate was encountered, with reasons for non-participation remaining undisclosed. It is speculated that large-scale farms may withhold their implementation techniques due to competitive market dynamics. Additionally, the absence of small-scale farm participation in the VOAC, primarily due to their lack of GAP certification, further contributes to the limitation.

The limitation of this study is compounded by the absence of publicly available statistics detailing the total number of RWA and RAU farms, encompassing both broilers and swine, along with their annual production capacity in different years. This lack of data further complicates our efforts to assess the broader impact and discern any trends in the coverage of VOAC. Additionally, the dearth of specific information regarding the locations of these farms presents significant challenges in comprehensively evaluating the distribution and impact of these programmes. Furthermore, external factors such as disease outbreaks in poultry and swine also influence the implementation of VOAC, contributing to the complexity of our analysis. Consequently, this limited insight impedes our understanding and hinders strategic planning, comprehensive evaluation, and programme improvement initiatives.

Further research is imperative to evaluate various aspects related to reduced antibiotic use and the potential economic implications associated with RWA and RAU certifications in Thailand. Specifically, there is a need to investigate the investment costs, as well as the economic benefits and incentives associated with the adoption of these certifications. Additionally, exploraing the premium prices of RWA and RAU products in the market would provide valuable insights into consumer preference and market dynamics. Conducting such researches will contribute to a better understanding of the overall impact and sustainability of these certification programmes in the context of Thailand's agricultural sector.

Recommendations

Our study is constrained by the challenge of determining the extent of farm participation, compounded by a dearth of hard, comprehensive and publicly available statistics. This challenge impedes our ability to fully comprehend the impacts of the RWA and RAU programmes on overall antimicrobial consumption and the overall effectiveness of these initiatives. Given these limitations, this study offers several recommendations

Optimising the certification strategy

In optimising certification strategies, it is recommended to maintain RWA and RAU certification if there is demonstrated farmer interest in DLD certification over the NSF, take into account potential investment costs and economic gains by farmers. Further investigation into farmer motivations and barriers for RWA and RAU certifications enrollment is crucial. Future studies need to address data gaps, particularly the economic impacts on farmers including mortality and productivity, quantifying actual antimicrobial usage reduction and implementing more effective promotion strategies, will provide evidence for policy decisions and assist farmers in RWU and RAU.

Enhancing monitoring and evaluation

The DLD should strengthen its monitoring and evaluation mechanisms for the VOAC programme to address existing challenges effectively. This includes regular monitoring of farm participation and annual assessments of programme outcomes by provincial livestock officers.

Increasing communication and consumer awareness campaign

The DLD should prioritise improving policy communication efforts to increase awareness of the RWA-DLD certification and antibiotic-free products among Thai consumers. This can contribute to fostering consumer trust and demand for such products in the market. DLD should launch a consumer awareness campaign to promote the RWA logo for poultry and swine products, thereby incentivising more farms to participate in the VOAC programme.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The study was approved by the Institute for the Development of Human Research Protections for research ethics clearance (Ref.no. IHRP2021168). The interviews were conducted in Thai through video conference and audio-recorded after verbal consent.

Author contributions

AL: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. SKi: Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. WK: Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. SKh: Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. RM: Conceptualization, Supervision, Validation, Writing – original draft, Writing – review & editing. VT: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2024.1375127/full#supplementary-material

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Realities, perceptions, and strategies for implementation of an ethical population management program for dogs and cats on university campuses

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Stray dogs and cats pose significant challenges for public health and animal welfare due to their potential involvement in zoonotic disease transmission, accidents, and aggressions. Large urban centers exacerbated challenges due to the presence of these animals in public areas with high human density. Ethical Population Management Programs (EPMP), rooted in the One Health approach, are crucial for addressing this issue comprehensively. This study aimed to demonstrate the approach on cats and dogs EPMP and evaluate the perceptions of academic community regarding EPMP implementation on a campus situated in urban territory. The study was conducted at the Pampulha campus of UFMG in Belo Horizonte, Brazil. In response to issues of animal abandonment and conflicts, the Permanent Commission for Animal Policies (CPPA-UFMG) was established in 2019 to manage the campus's dog, cat, and wildlife populations. The commission implemented the Trap-Neuter-Return (TNR) method, along with health assessments and vaccinations for animals. Interviews were conducted with campus staff to gauge their perception of animal management strategies. Retrospective and prospective analyses of the commission's actions were carried out to assess implementation processes and challenges. The animal population survey conducted on campus between July 2018 and September 2021 revealed a total of 266 animals recorded. Among these animals, 195 were cats (73.3%) and 71 were dogs (26.7%), with the majority being adults. Subsequent surveys in

2019 and 2021 showed a slight increase in the animal population, with measures such as sterilization contributing to population control. Perception analysis among campus users indicated strategies such as TNR were widely endorsed for population control. The employees perception questionnaire was applied to 115 individuals, representing 42 units/departments and five gates. Associations were found between these beliefs and support for institutional actions. The majority favored sterilization (92.17%) and agreed that TNR is an appropriate approach to population control. Overall, the study reflects a community concerned about animal welfare and supportive of measures to address population management and cruelty prevention. The continuous efforts of the university's CPPA have led to stability in the resident animal population, indicating success in achieving population control objectives.

KEYWORDS

veterinary public health, one health, community animals, perception evaluation, campus university

1 Introduction

Stray dogs and cats lacking basic health care assistance represent a challenge for public health management and animal welfare, as those animals could be involved in zoonotic disease transmission, accidents, aggressions such as bites and scratches, as well as property damage (1–4). It is estimated that 10% of dogs in urban and rural areas in Brazil do not possess a responsible owner, with significant variations, potentially reaching values close to 37% (5).

The challenge is exacerbated in large urban centers, where these animals are present in public areas with high human density (6). University campuses, for example, when they have large territorial extensions and many preserved green areas, may facilitate abandonment, and even though they are not suitable places for domestic animals to stay, many of them, after being abandoned, survive, and may be involved in academic community conflicts. As a solution, Ethical Population Management Programs (EPMP) are necessary, which should be based on the premise of One Health, that is, the interface between human, animal, plant, and ecosystem health (7), and therefore encompass actions that consider political, behavioral, ecological, sanitary, and socio-environmental aspects (3).

A globally disseminated method of ethical population management, especially for the control and stabilization of feral cat colonies, is known as Trap-Neuter-Return (TNR). This technique consists of a non-lethal strategy, where the animal is captured, surgically sterilized, identified, registered, and returned to its original community. The method exists because it is not feasible to promote the adoption of all stray animals and relies on the Vacuum Effect Theory, which states that by permanently removing animals from an environment, if there are other stray animals, there would be an influx of new individuals with unknown reproductive and health conditions, leading to an uncontrolled cycle, as the location allows these new animals to benefit from the environmental conditions necessary for life maintenance, such as shelter, water, and food (8, 9). There are variations of TNR that involve vaccination, deworming, and other necessary veterinary care, such as testing for Feline Immunodeficiency Virus (Fiv) and Feline Leukemia Virus (FeLV), rabies vaccination, sterilization, and returning to the original location for cats (10, 11).

TNR has been the method of choice for managing the population of cats on university campuses in other countries, such as in the USA at Texas A&M University (12) and the University of Central Florida (13); at the University of KwaZulu-Natal in South Africa (14); at the American University of Beirut and Lebanese American University in Lebanon (11); and at the University of South Wales in Australia (10).

Although less common, there are studies in the literature that demonstrate TNR programs involving dogs in urban centers, such as in the Hong Kong SAR (Special Administrative Region), where the Society for the Prevention of Cruelty to Animals (SPCA) managed to sterilize 75% of the free-roaming dog population and return all that were possible to their original location (15); and in Greater Bangkok, which in 5 years of high-intensity catch, neuter, vaccinate and return interventions, the free-roaming dog density was reduced by 24.7%, while the monthly average of canine rabies cases reduced to 5.7% (16).

Despite the various possibilities associated with campus domestic animal management practices, the methods applied should be evaluated from perspectives of qualitative and quantitative indicators, which are included as important measures in veterinary epidemiology (17). According to Garcia, Calderón, and Ferreira (3), diagnosing the situation is the first step in building a population management program, as it allows for understanding the reality on which one intends to act and proposing interventions. For this, it should involve data collection on the animal population (population dynamics) and human attitudes and behaviors regarding animals.

Qualitative and quantitative methods of health indicators are important, especially in evaluating changes after the implementation of certain practices, signaling whether the proposed objectives were or are being conducted appropriately (18, 19). In Brazil, the humane and ethical management of animals in institutionalized settings is not a reality in most universities. The Federal University of Minas Gerais, located in a Brazilian metropolis, pioneered the creation of its Policy for Ethical Population Management of Stray Domestic Animals and Wildlife Surveillance on Campuses in 2018, opting for the TNR method along with other actions, thereby establishing a comprehensive

yet effective Program for Humane and Ethical Management of Domestic Animals.

This study aimed to demonstrate the approach on cats and dogs population management and evaluate the perceptions of university security guards, cleaning professionals, and animal caretakers regarding EPMP implementation on a campus situated in urban territory.

2 Materials and methods

2.1 Study area

The study was conducted on the Pampulha campus of the UFMG (Figure 1), founded in 1962, which houses one of the largest green areas in the city of Belo Horizonte, Minas Gerais, Brazil. Its terrain covers approximately 3.3 km^2, accommodating 22 academic units, 21 administrative units and their departments, as well as communal and utility spaces such as university restaurants and the service plaza. Around 50,000 people circulate through the Pampulha campus on a typical school day (20). It is surrounded by urban, residential, and commercial areas inhabited by people from various levels of social vulnerability.

There are reports that sighting of new animals on the campus has always occurred, as well as conflicts arising from their presence, sometimes resulting in serious cases of mistreatment of dogs and cats, as well as attempts at mass extermination, even in relatively recent times.

In mid-2018, in response to the scenario of abandonment and conflicts with the presence of animals, a commission was created by the university administration to draft a policy for the university, and in 2019 this became the Permanent Commission for Animal Policies of UFMG (Comissão Permanente de Políticas de Animais, CPPA-UFMG), aiming for an ethical population management of dogs and cats residing on the campus, as well as the wildlife population vigilance (21). In 2020, the actions of the Commission were formalized through an Extension Program composed of collaborators, including faculty, students, and administrative staff. For management, the decision was made to implement the TNR method, including testing cats for Feline Immunodeficiency Virus (FIV) and Feline Leukemia Virus (FeLV), and dogs for visceral leishmaniasis (VL), all through immunochromatography-based screening tests, resorting to confirmatory serological testing if necessary, and rabies and species-specific polyvalent vaccination, ear-tipping of cats, placement of identification collars on dogs, and subcutaneous implantation of microchips in both species. Thirty-four feeding points were defined and standardized on the campus, in less visible locations, with daily maintenance by volunteer members of the commission.

Among the main objectives of the Management Program are increasing life expectancy, a common goal of community animal programs; increasing community engagement; reducing births, diseases, and deaths; and decreasing abandonment.

2.2 Animal population survey

Once a year, a census was conducted across the entire campus area using three methodologies:

a Notification of each animal by appointed collaborators (unit's directors, gatekeepers, and university security guards) through a messaging app to register all animals present in the unit during the month of September yearly.

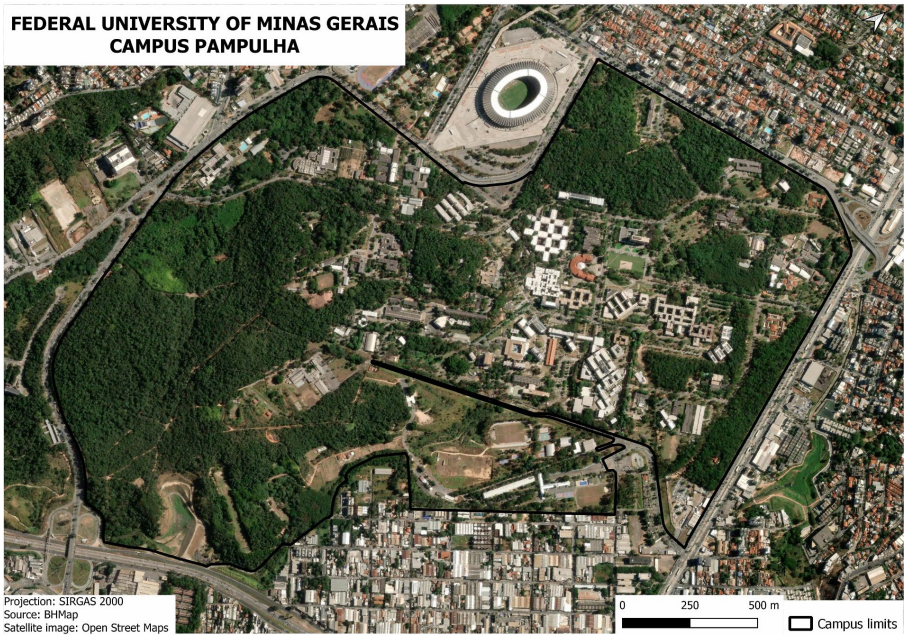

FIGURE 1
UFMG's Pampulha campus map with units and entrances which the questionnaire was applied.

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TABLE 1 Minimum number of questionnaires to be administered, according to sample calculation, to employees in the security, gatekeeping, and cleaning sectors of the Pampulha campus of UFMG, 2021.

Employees on Pampulha campus, UFMG			
Position	Campus sample	%	Minimum sample to be applied
Cleaning professionals	231	31.77%	31
Security guards	156	21.46%	21
Gatekeepers	340	46.77%	45
Total	727	100.00%	97

b On-site observation for 1 week, at two different moments (morning and evening), 5 days a week, with two researchers walking and driving along the university route, taking photographic records of the animals sighted.
c Installation of cameras trap at feeding sites in each unit to record elusive animals.

The created database contained information about the animal (species, apparent age, sex, apparent health status, behavior, reproductive condition), date, time, and the unit or area where it was sighted. Subsequently, as other actions were taken regarding animal's management, new data were recorded, such as the date of surgical sterilization, vaccination, deworming, and outcomes (release, adoption, referral to temporary home, euthanasia, and death).

2.3 Perception of users and employees

Interviews were conducted with university security guards, cleaning professionals, and gatekeepers, with a sample calculation to define a simple proportion using the Epitools tool[1] according to Thrusfield (22). The calculated sample size was a minimum of 97 respondents, considering an infinite population size and a 10% margin of error. This minimum number was proportionally divided among the campus staff (Table 1).

Regarding the existing commission members until the year 2021 ($N = 18$), according to the sample calculation, at least two interviewees would be necessary. However, due to the ease of access and availability of individuals to participate in the study, all representatives from campus units were interviewed. The study period coincided with the coronavirus pandemic (SARS-CoV-2) and coincided with the presence of only essential activities on the Pampulha campus, justifying the selection of these professionals for the perception research as they were present in their units during the first year of Program implementation.

A semi-structured questionnaire containing 39 questions was developed (Supplementary material). A pilot test was conducted with collaborators from the School of Veterinary Medicine at the UFMG to ensure it could be administered by interviewers and understood and answered by respondents (23).

Variables related to the location (unit or work area of the interviewee and whether it was associated with the Commission), demographic aspects such as position/function, gender, age group, education level, and length of service in the location were analyzed, as well as perception regarding population management methodologies of dogs and cats and responsible pet ownership.

The interviews took place between September 8th and October 5th, 2021, in person.

2.4 Implementation of the commission analysis

A retrospective analysis was conducted on the commission's actions from its inception in July 2018 to September 2021, using documents generated from meetings and activities, as well as gathering information through dialogues and discussions with long-standing commission members. Additionally, a prospective monitoring was carried out from October 2021 to December 2023, tracking the actions and meetings of the CPPA. All produced content was recorded in a database and utilized to generate information about the commission's implementation process, including observed challenges, strengths, and the consolidation of actions thus far.

2.5 Data analysis

The data was tabulated and subjected to frequency analysis, followed by Pearson's chi-square and Fisher's exact tests to verify associations. If significant, pairwise comparisons were conducted using standardized residual analysis. Associations were considered significant when the residuals exceeded 1.96 (24). All analyses were performed using Stata/MP version 16.0 (STATACORP LLC), and significance was set at $p \leq 0.05$.

3 Results

3.1 Implementation of the dog and cat management program at UFMG

The records of documents and meetings from the Commission demonstrated that, by 2023:

1 Meetings were held with all directorates to sensitize unit managers and appoint collaborators in each of them.
2 Subcommission were created so that each collaborator could perform specific functions within the Commission (Animal registration and identification, Feeding, Animal population management, Clinical and surgical management, Animal disposition/placement, Wildlife monitoring, Education, and Financial).
3 The appointment of collaborators was done according to everyone's involvement and skills in animal welfare.
4 Standardization and monitoring of feeding points by caregivers in each unit were implemented.
5 Continuous education initiatives on health and animal welfare were promoted for the collaborators.

1 https://epitools.ausvet.com.au/oneproportion

6 Actions to deter abandonment were carried out: permanent signs at the five main campus' entrances, gatekeepers training, and, educational initiatives focusing on the academic community, including the distribution of an online handbook.
7 Ensure a quick pickup, sterilization, identification, and release of newly sighted animals: sterilization was covered by University, using funds allocated by the Rectory, while some animals were also included in the Sterilization Program run by the local City Hall or through partnerships with veterinary clinics.

Continuously, educational actions for the academic community and the external public were carried out, in partnership with the municipal public service, as the origin of most of the animals was abandonment, and they found access to food, water, and shelter on campus, with conditions for survival, even if not always ideal. Furthermore, signs were implemented at all entrances, informing about the criminal nature of animal abandonment.

Among the facilitating points identified in the implementation of the UFMG Management Program, the following stood out:

i) Establishment of a Permanent Commission by the university's board, which ensured the continuity of actions regardless of the occupants of the position and the philosophy of each administration;
ii) Appointment of collaborators in each academic or administrative unit, all designated by the management and with acceptance mediated by signing a Free and Informed Consent Form, in order to institutionalize the process of surveillance and care for the animals;
iii) Formalization of an Extension Program in the University's Extension Board Office, in order to ensure certification for participation time to all commission collaborators;
iv) Division of tasks into eight working subcommission (registration and identification, feeding, population management, clinical and surgical management, destination, wildlife vigilance, education, and finances), allowing collaborators to organize themselves into groups according to their skills and preferences;
v) Collaboration of the university veterinary hospital on the Pampulha Campus, which plays a significant role in the actions of the Management Program;
vi) Partnership with the Belo Horizonte City Hall, through the Center for Zoonosis Control;
vii) Cooperation from the Integrated Residency Program in Veterinary Medicine on the UFMG Pampulha campus, with active participation of Public Health residents in all actions of the Permanent Commission.

Among the challenging points highlighted during the implementation of the UFMG Management Program:

i) Difficulty in managing personal relationships and divergent thoughts within the group of 45 volunteers, who had different professional backgrounds and distinct beliefs regarding animal care. The solution to minimize this issue was to conduct training sessions to level up everyone's knowledge, especially on the T.N.R. technique, the no-shelter policy, and ear tipping, which sparked considerable prejudice due to a lack of technical understanding;
ii) Motivating the 45 volunteers to actively participate in the Program, as some were appointed by the directorates but were not inherently motivated. While they were a minority, their lack of engagement triggered comparisons among more active members, leading to feelings of overload and fatigue risk. The solution to this problem was to hold private meetings with some volunteers and the directorates, urging them to take responsibility for the animals in their unit;
iii) Resource acquisition: undoubtedly, this is the major obstacle to the Management Program's actions. After receiving the initial funding in 2020, which lasted a year and was used to manage 100 animals, there was a need to supplement the resources with new strategies devised by the commission. The annual management plan sent to the University board did not include provisions for clinical and surgical care for campus animal incidents, such as vehicular trauma, severe illnesses, and other affections. Therefore, sponsorships and new fundraising methods were necessary. The strategy to alleviate the resource shortage was to establish a financial subcommission to plan and manage resources from promotional events and new sponsorships.
iv) Controlling new abandonments: due to the campus's vastness, pandemic isolation, and lack of surveillance cameras at various points, new abandonments were still observed at UFMG. The solution to this problem was intensive training for surveillance, gatekeeping, and cleaning professionals, along with the installation of anti-abandonment signs and improvements to surveillance cameras in each unit.

3.2 Animal population survey

Among the quantitative data from the work carried out on campus, from July 2018 to September 2021, 266 animals were recorded (approximately 6.8 new animal records per month), in 25 different units or areas, of which 195 were cats (73.3%) and 71 were dogs (26.7%), with 71% (189) adults. All the animals were new sightings, as the method of photographic recognition with confirmation by the caretakers and commission members was used, resulting in the insertion of new entries into the database based on this criteria. Figure 2 shows the number of new sightings of dogs and cats recorded in our database by period, and it is important to note that animals sighted previously or that have settled on the campus are not included in subsequent periods. There is no information about the destination of all the animals sighted on campus during the study period, since many were seen only once, which may indicate that they passed through the university space, were recorded in the database, but did not settle there.

Surgical sterilization, rabies and polyvalent vaccination were performed, as well as FIV/FeLV tests in felines and visceral leishmaniasis in canines, for 97 cats (38 males and 59 females) and 27 dogs (13 males and 14 females). Through the CPPA, 47 adoptions (17.7%) were mediated during the period, with 38 cats and 9 dogs. There was a 26% increase in adoptions in the first year of the CPPA-UFMG, compared to the year before its implementation.

The units have established locations for feeders and drinkers for the animals, which are standardized and monitored by the Commission, as well as the establishment of protocols and flowcharts,

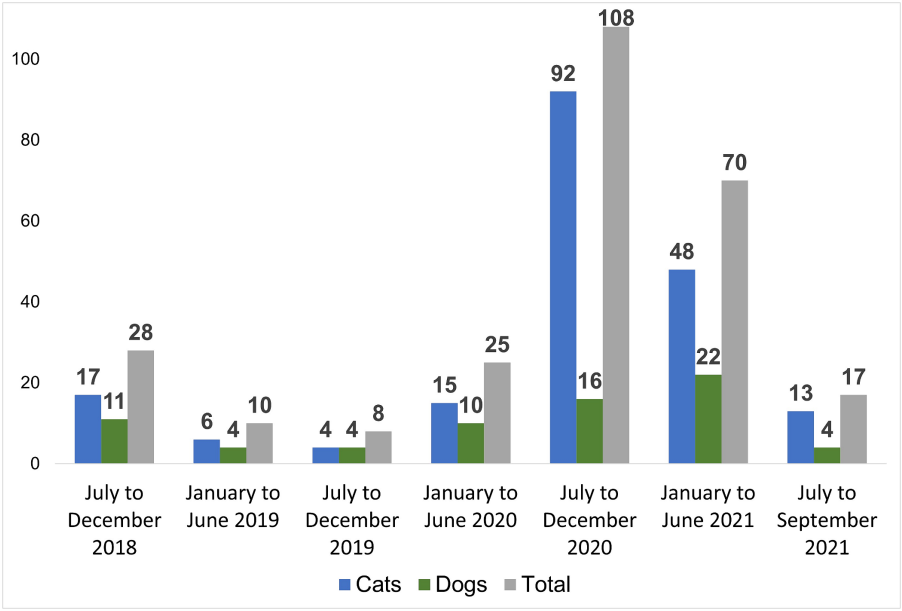

FIGURE 2
Number of new entries into the database by species between July 2018 and September 2021.

including feeding practices and water supply, and addressing events related to animal health. Educational activities for the academic community and the public have been developed in partnership with the municipal public service, as the origin of most animals was abandonment or migration from nearby regions, and they found access to food, water, and shelter on campus, conditions for survival, even if not always ideal. Conflict management among professors, animal protection technicians, and campus employees was resolved through access to information, dialogue, and standard operating procedures. There was an urgent need for the implementation of actions to prevent animal abandonment on campus. Signs were implemented at all entrances, and educational activities are ongoing consistently.

The first survey conducted in 2019 estimated that there were approximately 100 animals on campus, with 80 cats and 20 dogs. In the census conducted in 2021, through consultation with local representatives and unit caregivers, it was found that there were 104 animals in 21 campus units (Supplementary material), including 91 cats (41 males, 38 females, and 12 with no sex information) and 13 dogs (6 males and 7 females). There was an increase of four animals in 2021 compared to the census conducted in 2019. Considering the more efficient surveillance since the implementation of the Program, which increased the number of sightings, the small increase in the number of animals suggests a trend towards population stability on campus, probably with a significant influence from the activities carried out by CPPA-UFMG.

The sex ratio (male:female) among cats was 1.26:1 and among dogs was 0.86:1. Among the cats, 92.3% (84) were adults, and all dogs were adults. Regarding the number of animals present on campus in the 2021 census, 65.38% (68) were surgically sterilized. Of the total cats, 60.4% (55) were sterilized (80.5% of males and 57.9% of females). All dogs were surgically sterilized.

In the prospective study, in 2022, a new census was conducted on campus, covering all units, revealing 125 resident animals at 34 sighting points (117 cats and 8 dogs). A 100% sterilization rate was observed for these animals, as some had already been neutered in other periods at the time of the census, and all were vaccinated against rabies. Figure 3 demonstrates the number of animals neutered by the committee per year. This high sterilization rate was made possible through visits to the different focal points of the colony, dialogue with caretakers, monitoring by trap cameras to better understand the dynamics of movement within the territory, use of automatic activation Brazilian traps for capture, use of the manual drop trap DT1 from the company Tomahawk Live Trap for animals that did not enter the automatic trap, and a routine of night-time captures.

Five years after the implementation of the Commission, another census was conducted in 2023, and stability of the resident population on campus was observed – $N = 95$ animals (83 cats and 12 dogs), indicating that the continuous and systematic actions adopted by the CPPA are successfully achieving the population control objective.

3.3 Perception analysis regarding population ethical management actions of dogs and cats

The questionnaires were administered to 115 employees or users of the Pampulha campus, from 42 units/departments and five gates (Figure 4).

The detailed description of the questionnaire responses is provided in supplementary material. Most respondents (39.13%, 45/115) were gatekeepers and male (55.65%, 64/115). The age group with the highest number of participants was 32 to 38 years, followed by the 53 to 59 age group, which together accounted for 40.87% (47/115) of interviews. The most frequent level of education was completed high school (43.48%, 50/115), and the lowest was

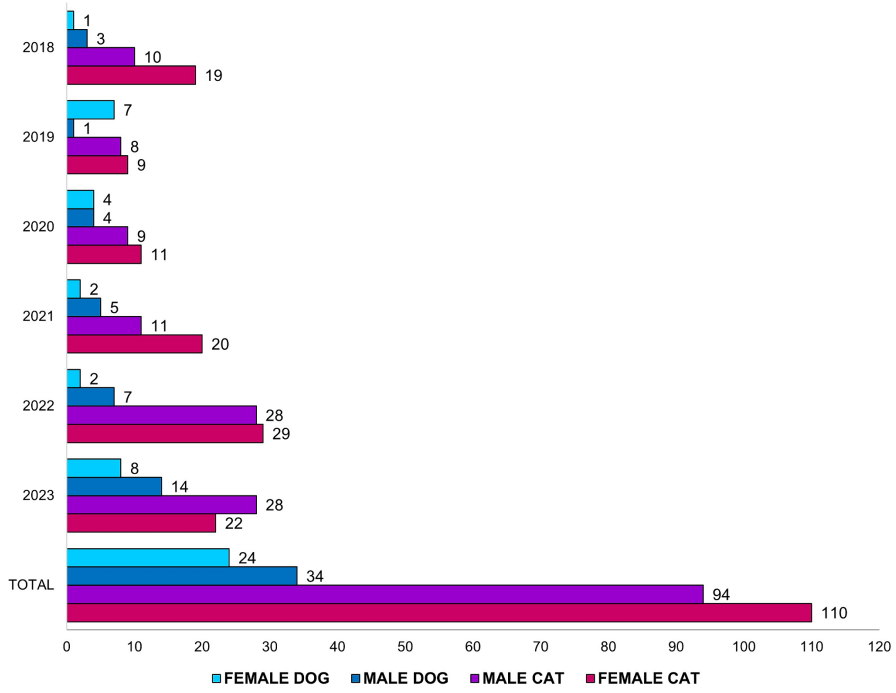

FIGURE 3
Quantitative of sterilizations per year, by species and sex.

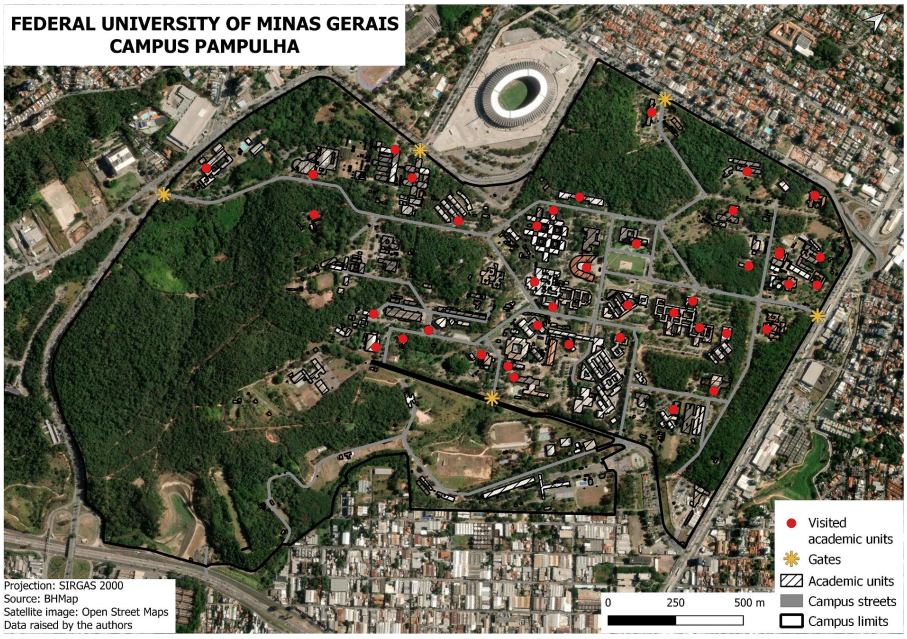

FIGURE 4
UFMG's Pampulha campus map with units and gates showing the areas of questionnaire application.

incomplete higher education (5.22%, 6/115). A large portion of respondents reported observing cats (83.48%, 96/115), and dogs (61.74%, 71/115) without owners in the unit or area where they work, a result consistent with the species distribution found in the campus resident population survey.

Regarding population management on campus, most respondents (70.43%, 81/115) believed that the university was responsible for the animals present in the units, considered it correct for the institution to assume responsibilities regarding them, and agreed with the animals residing on campus.

There was an association between believing that university assumed responsibility for the animals and considering it correct for the institution to do so ($p = 0.016$). Furthermore, there was an association between considering it correct for the university to assume responsibilities for the animals and agreeing with their presence on campus ($p = 0.028$). These associations demonstrate that most of the university community cares about the animals and agrees with institutional actions to promote animal welfare, characteristics of the work of CPPA-UFMG.

Regarding strategies to control the population of dogs and cats on university grounds, 55.65% (64/115) of respondents were in favor of removing the animals from campus, although this number was lower than the 92.17% who agreed with sterilization. Among those who disagreed with sterilization, reasons listed included not allowing the animal to have freedom or choice, as well as religious beliefs. Regarding the destination of the animals when removed from campus, many suggested handing them over to the city hall, non-governmental organizations (NGOs), or sending them for adoption. There was an association between favoring the remotion of animals from campus and being male ($p = 0.034$) with an age between 53 and 59 years ($p = 0.006$), as well as disagreeing with the method and being female ($p = 0.034$) with an age between 39 and 52 years ($p = 0.006$).

Concerning about ear tipping of cats and the use of collars with identification tags on dogs to recognize animals cared for on campus, 88.70% (102/115) of respondents agreed with the first method, and 95.95% (110/115) with the second, respectively.

A small proportion of respondents (8.7%, 10/115) had witnessed acts of animal cruelty in the unit or area where they worked, with the majority being commission against cats. Acts reported included threats, violence, and abandonment.

Regarding TNR most respondents (95.65%, 110/115) agreed that it is an adequate approach to reduce or prevent increasing in the population of dogs and cats on campus.

In relation to the return of animals to their original unit or area after surgical sterilization, 80% (92/115) of respondents agreed. There was a statistical association between agreeing with the return and the age of the respondent ($p = 0.016$), with an association between agreement and ages between 32 and 45 years and disagreement and ages between 46 and 52 years.

Finally, considering the concept of responsible pet ownership, more than 75% (88/115) were not familiar with the term, but when asked about knowledge related to crimes due to abandoning and mistreating animals, almost all respondents reported awareness.

4 Discussion

By 2018, actions related to abandoned animals on campus were carried out independently by professors and staff members who were concerned about the presence of sick and abandoned animals, in partnership with the Municipal Center for Zoonosis Control, using the T.N.R. methodology, supported by current state legislation. After reproductive and sanitary management, animals were put up for adoption, and when adoption did not occur, they were returned to the location where they were captures or rescued. However, the actions were not continuous, and reports of abandonment and mistreatment were constant.

From the creation of the Commission, actions were systematized in an integrated approach between the University and the municipal animal control service, ensuring constant surveillance, health, and welfare for the animals and the campus community.

A higher number of cats compared to dogs was observed at UFMG. The proportion of cats approached the studies conducted at the campuses of the University of Central Florida (25). The sex ratio of dogs differed from the ratio found in the study by Garcia et al. (26), in São Paulo, with animals in street situations, where the number of males was higher than that of females.

The proportion of adult animals on campus may indicate that the population is stable and without new births, as in other long-term T.N.R. programs, where the number of kittens in the colony was reduced to zero within a period ranging from 2 to 8 years (25).

All animals residing on campus were surgically sterilized. In units where all animals were sterilized, there were no puppies, in line with the information that the higher the sterilization rate, the lower the number of puppies (14).

According to Amaku et al. (27), for dogs, in management programs where high sterilization rates are applied, such as 80% per year, it would take a period of 5 years to decrease animal density, and according to Miller et al. (28) for cats, sterilizing 40% of the animals per year, in the long term would result in an accumulated sterilization rate of 75%. This could be achieved at UFMG if there were no high annual abandonment rates or measures that prevented the migration of animals from the regions near the campus. Therefore, education and surveillance actions must remain continuous and, if possible, be intensified each year.

In working done by Little et al. (29), testing animals for FIV and FELV in TNR programs is not recommended, since one of the premises of this type of population management involves sterilization, which prevents the transmission of FELV from the mother to the offspring and of both diseases in fights between males, important routes for maintaining the disease. Thus, the resource can be directed to the greatest possible number of sterilizations (29). In line with the recommendation, since December 2023, there has been no more testing of the cats managed by the UFMG commission, except for those that are referred for adoption.

Regarding the perception of campus employees, the associations found between believing that UFMG took responsibility for the animals, agreeing with their presence on campus, and considering it correct for the institution to manage the population of these species showed that most of the university community cares about animals and agrees with institutional actions to promote animal welfare, characteristics of CPPA-UFMG's plan of action. Izaguirre and Montiel (30), in their perception study regarding animals on the campuses of the Autonomous University of Yucatan, Mexico, found that about half of the respondents believed that university authorities should be responsible for the dogs and cats residing on campuses.

Most of the employees were also in favor of removing animals from campus and delivering them to public or philanthropic shelters, with the majority being male, regarding the perception of strategies to control the population of dogs and cats on university grounds. The result is similar to the study conducted by Ash and Adams (31) at Texas A & M University, United States, and Kim et al. (32) in South Korea, where most respondents who agreed with animal removal as a management method were men. There was an association between disagreeing with animal removal and being a woman aged 39 to 52, which corroborates with the study conducted in Belgium, associating

being female with a positive response to a community cat program on a university campus (33).

Regarding the forms of animal identification on campus, despite the recognition of collars in dogs achieving higher agreement, a significant fraction of respondents agreed with ear-tipping in cats, demonstrating an understanding and importance of this strategy. This practice, although widely adopted worldwide, faces resistance due to its aesthetic implications or consideration as an act of mutilation (34), which should not occur with the adequate anesthetic technique and local pain management.

There was greater agreement among respondents that T.N.R. would be a great strategy to decrease or prevent the increase in the population of dogs and cats on campus. There was no association with the gender of respondents among those who agreed with the methodology, unlike the results of other studies where more women supported T.N.R. as a method for population management (31, 35).

Few respondents were familiar with the concept of responsible ownership, but most knew that abandoning and mistreating animals are crimes. These data are important from the perspective of perception and association with injuries and mistreatment, as knowledge about responsible ownership is a factor that influences the reduction of domestic animal exposure to diseases (36), as well as in the expectation of effort for the management of an animal (37). Therefore, it is important to maintain education strategies focusing on responsible animal ownership (38).

5 Conclusion

The ethical population management of dogs and cats is a challenge for public health politics nowadays and should be based on evidence and indicators, so that the results can be measured and the evaluations of the efforts provide a basis for the next steps to be taken, since the management program must be a continuous, uninterrupted and transdisciplinary work.

Since its creation in 2018, CPPA-UFMG has been conducting actions for the ethical population management of dogs and cats on the university campuses. At the Pampulha campus, until the halfway point of implementation (September 2021), many animals, mostly cats, were recorded in 25 different units or areas. The effectiveness of surgical sterilization practices for approximately half of these animals observed during the period, and the nearly one-fifth of the animals being adopted, qualitative evaluation has become an essential tool for progress and the possibility of altering the implemented practices.

Perception research has shown that, despite the smaller portion of respondents being aware of the CPPA in the first year of implementation, the vast majority agreed with the T.N.R. methodology defined for the ethical population management of dogs and cats present on campus. Understanding what the human population perceives, which coexists with the animals in the spaces targeted by population management interventions, was important for directing educational actions to the most sensitive topics and ensuring success, reducing conflicts, and establishing collective agreements for the Program's objectives.

After 5 years of implementation of the Management Program, it was observed, when compared to other studies, promising results that the actions at the Pampulha campus are successful, with the sterilization of 100% of residents and population stability.

In light of the results of this work, it is noted that people's perception can align with what theory advocates, simply by giving a name to what is already present in the collective imagination, and when necessary, through education, planting the seed of cultural change that is expected, so that we can approach the world we envision, for ourselves, for the animals, and for the environment.

The challenges of ethical population management at the Pampulha campus of UFMG increase because, as the number of people involved in the work grows, so does surveillance and monitoring, which generate more occurrences to be addressed. Diversity in opinions and ways of acting also grows, inspiring better management of the human resources involved. Science is what should underpin the actions, but without humanity, there is no task worthy of effort. Listening to people and putting ourselves in their shoes leads us to see, in their way, the world that we are accustomed to seeing in our own way, and therefore, as Saramago taught, "to know things, you have to turn them all around."

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Research Ethics Committee from UFMG by the protocol 3,356,456. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. The animal studies were approved by Committee on Ethics in Animal Use (CEUA) from the UFMG by the protocol number 60/2022. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the owners for the participation of their animals in this study.

Author contributions

GB: Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. LO: Formal analysis, Validation, Writing – review & editing. CO: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. AC: Conceptualization, Validation, Writing – original draft. CB: Conceptualization, Writing – original draft, Validation. CT: Data curation, Methodology, Writing – review & editing. CM: Conceptualization, Writing – original draft. FS: Conceptualization, Writing – original draft. GL: Conceptualization, Writing – review & editing. LM: Data curation, Methodology, Writing – review & editing. LV: Writing – original draft. MC: Writing – original draft. RF: Writing – review & editing. VG: Writing – review & editing. WB: Data curation, Methodology, Writing – review & editing. YO: Data curation, Methodology, Writing – review & editing. DS: Conceptualization, Formal analysis,

Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Investigating the workforce capacity and needs for animal disease surveillance and outbreak investigation: a mixed-methods study of veterinary services in Vietnam

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The need for strengthening national capacities for disease prevention, preparedness, and response is increasingly becoming urgent. Central to this is strengthening existing systems and workforce capacity for disease surveillance and disease outbreak response. This study aimed to evaluate the national capacity and needs of veterinary services in Vietnam in animal disease surveillance and outbreak investigation skills. A cross-sectional, convergent, mixed-methods study was conducted between November 2020 and April 2021. An online questionnaire was administered to government field veterinarians, followed by descriptive and multivariable analyses to understand field capacity, specifically levels of experience in outbreak investigation and animal health surveillance. Semi-structured interviews were conducted with various stakeholders in veterinary services and interview transcripts were coded and thematically analyzed. Qualitative results were used to contextualize quantitative findings from the survey. Overall, 178 field veterinary staff completed the online survey, and 25 stakeholders were interviewed. Eighty percent of respondents reported a high priority for further training in both animal disease surveillance and outbreak investigation. Training and competence were more limited at the district and commune levels, highlighting a gap in capacity at the subnational level. Reasons included a lack of in-depth training opportunities, limited access to resources and high staff turnover. Respondents who completed postgraduate qualifications in epidemiology or Field Epidemiology Training Programs were more likely to have higher levels of experience in animal health surveillance and outbreak investigation. This study identified gaps in knowledge and adoption of practices most often related to local-level or less experienced veterinary staff with limited training opportunities in epidemiology. Findings inform the prioritization of training and planning activities to further enhance the national capacity of veterinary services in Vietnam. Underlying explanations for existing gaps in capacity include inequities in skill development and training opportunities

across levels of veterinary staff, gaps in the chain of command and unequal funding across provinces.

KEYWORDS

animal disease, surveillance, outbreak investigation, veterinary epidemiology, Vietnam, global health security

1 Introduction

The need for strengthening country capacity for pandemic prevention, preparedness, and response is increasingly evident following the recent COVID-19 pandemic. Central to this is strengthening existing systems and both medical and veterinary workforces for disease surveillance and disease outbreak response. Surveillance is required to understand disease transmission and distribution of endemic diseases and ensure early detection of (re-) emerging diseases. Capacity in outbreak investigation is critical for timely response and containment of disease threats so that further transmission and future outbreaks in animal and human populations can be prevented. The key to strong surveillance and response systems is a trained and skilled workforce to ensure countries meet the World Health Organization's (WHO) International Health Regulations (IHR 2005) (1) and World Organization for Animal Health's (WOAH) Performance of Veterinary Services (PVS) standards, and strengthen overall animal and human health infrastructure (2, 3).

The Asia-Pacific region is recognized as a hotspot for emerging infectious diseases (EIDs) (4). In particular, Vietnam is a potential hotspot for zoonotic diseases (including those with pandemic potential) and is recognized as an epicenter for EIDs (5). More than 60% of human infectious diseases and 75% of EIDs are zoonotic (6, 7). Vietnam has experienced a rapid and radical transformation of its livestock production systems, including intensification of production and increases in poultry and pig populations following economic reforms initiated in the 1990s (8, 9). Intensification increases the risk of disease emergence and amplification through increased population size and density (10). Outbreaks of both zoonotic diseases and transboundary animal diseases (TADs) are of importance given their significant human health and socioeconomic consequences, especially with higher economic dependence on agriculture, mainly small-scale farming and livestock husbandry in Vietnam (11). For instance, the highly pathogenic avian influenza (HPAI) outbreak of 2003 (12) and the African swine fever (ASF) outbreak of 2019 have shown the devastating socioeconomic impact of animal disease outbreaks on farmers' and producers' livelihoods and the wider economy. Antimicrobials are also often used within intensive farming systems to treat disease, for growth promotion and disease prevention, leading to a rise of antimicrobial resistance (AMR) and transmission of resistant bacteria (including zoonotic agents) (13). These threats raise concerns for global security and their management requires input from multiple disciplines or a cross-sectoral approach (14, 15). Reliable information is required to better understand the disease threats, the magnitude of their impact, which populations are at risk and how these threats can be better controlled and prevented. Robust animal health surveillance systems are central to providing this information. Following this, a competent workforce and mechanisms need to be in place to respond to and contain outbreaks.

This study was undertaken as a part of a regional capacity and needs assessment conducted in six countries in the Asia-Pacific region by the Asia Pacific Consortium of Veterinary Epidemiology (APCOVE) (16). Specifically, this study was conducted to understand the current epidemiological capacity of field veterinary staff in Vietnam in animal health surveillance and outbreak investigation. The findings allowed us to identify factors associated with higher levels of experience in core competencies of field epidemiology, thereby providing insight into factors that may strengthen local capacity and identify existing gaps. More than ever, there is recognition that regional capacity in veterinary epidemiology is fundamental to building resilience against the global infectious disease threats (17, 18). By using this knowledge, we can prioritize aspects of training required for field veterinary staff in Vietnam.

2 Materials and methods

2.1 Study area

This study was conducted in the Socialist Republic of Vietnam, Southeast Asia. There are eight subregions and 63 provinces in the country, which are administratively divided into districts and communes (19). At the central level, the Department of Animal Health (DAH) is part of the Ministry of Agriculture and Rural Development (MARD), which has responsibility for seven Regional Animal Health Offices (RAHO). Vietnam has a decentralized system of autonomous provinces, governed by the local People's Committee (20). The provincial Sub-Departments of Animal Health (Sub-DAH) are under the administrative management of the Department of Agriculture and Rural Development, and manage District Veterinary Stations, which have links with commune veterinary teams (21).

2.2 Study design

This cross-sectional study used a convergent mixed-methods study design, in which quantitative and qualitative data collection and analysis were carried out at similar times, followed by an integrated analysis to cross-validate findings (22, 23). The quantitative phase used a questionnaire administered online, whereas the qualitative phase consisted of semi-structured interviews conducted either face-to-face or using video teleconferencing software. The study was carried out between November 2020 to April 2021.

2.3 Data collection and analysis

The methods of this cross-sectional convergent mixed-methods study have been published previously in detail (24). Briefly, an online questionnaire was designed and administered to field veterinary staff in Vietnam via REDCap survey platform (25). The questionnaire was divided into eight sections, each focusing on a different core epidemiology competency and the respondent's demographic information. The eight sections focused on: [1] outbreak investigation, [2] animal disease surveillance, [3] data management and analysis, [4] epidemiological surveys and studies, [5] One health, [6] leadership and communication, [7] use of biosafety and biosecurity methods and [8] demographics. In this study, findings from the sections related to animal health surveillance and outbreak investigation are presented. Findings from other sections have been published elsewhere to allow more in-depth analysis of the results (24). The questionnaire can be found in Supplementary materials. Questionnaire responses were exported into a Microsoft Excel® spreadsheet and cleaned and analyzed using R Studio v 1.4.1717, an integrated development environment for R (26). Findings from other sections have been published elsewhere (24) to allow more in-depth analysis into the results.

Two outcome variables representing the level of experience in: (1) animal health surveillance; and (2) outbreak investigation were created by assigning scores to respondents based on their answers to questions about the frequency of participation in activities during the past 12 months (Supplementary Tables S2–S4). A score of 0 was given for a response of never or rarely participating and a score of 1 was given for a response of participating once per month or more than once per month. The scores for each respondent in animal health surveillance and outbreak investigation competencies were then summed and categorized into a binary outcome variable. For the analyses of the level of experience in animal health surveillance and outbreak investigation, a respondent was defined as having none-to-low levels of experience if their total score was zero and a moderate-to-high level of experience if their total score was greater than zero.

Our aim was to better understand respondent characteristics associated with the binary outcome variables representing level of experience in animal health surveillance and outbreak investigation, as described above. To do this, descriptive analyses followed by binary logistic regression modeling were used. Two logistic regression models were developed. The first was for animal health surveillance and the second for outbreak investigation. Candidate explanatory variables (that is, respondent characteristics associated with the level of experience for each activity) were as follows. Respondent age (18–34, 35–44, ≥45 years), gender (female, male), work role (district veterinary officer, provincial veterinary officer, other), education level (bachelor, diploma or other, postgraduate), years since graduating from university (<5, 5–9, 10–14, 15–19, ≥20 years), formal epidemiology training completed (no/yes), formal epidemiology workshops attended (no/yes), postgraduate qualification in epidemiology or completion of Field Epidemiology Training Program (no/yes) and job tenure (0–9, 10–12, ≥13 years).

Univariable logistic regression models were fitted to identify associations between each of the candidate explanatory variables and level of experience. Candidate explanatory variables with $p < 0.20$ were retained for multivariable analyses. Candidate explanatory variables with >10% of their data missing were excluded from further analyses. Multivariable models were developed using a manual forward stepwise selection procedure and only those variables with $p < 0.05$ were retained in the final model. Non-significant variables from the stepwise procedure were re-tested in the final model to confirm their non-significance. Potential confounders, including age, gender and education level were added to the final models if the parameter estimates of the other variables in the model differed by >20%. Biologically relevant interactions between explanatory variables were tested in the final model and retained only if statistically significant ($p < 0.05$).

The semi-structured interviews were conducted with stakeholders in veterinary services, including government, academia, research institutes, non-profit and international organizations to contextualize survey findings. Verbal consent was provided by each participant before commencing the interview process and audio recording interviews. Guiding questions asked within the interviews focused on topics including the general structure of veterinary services; Field Epidemiology Training Program (FETP) or equivalent training programs existing in-country; capacity of veterinary services to detect and respond to outbreaks, conduct animal health surveillance, implement biosecurity and biosafety measures, and collaborate with the public health sector or workforce. Coding and thematic analysis using a deductive approach were performed using NVivo software (NVivo version 12, QSR International Pty Ltd). The same approach for analysis was applied to the qualitative data collected from interviews and the free-text responses provided by respondents in the online survey. Findings from both were then integrated and presented.

2.4 Ethics statement

Ethics approval for the study was obtained from Human Research Ethics Committee at the University of Sydney (project number: 2020/459). There was no requirement to obtain additional local approval in Vietnam.

3 Results

3.1 Sample characteristics

The demographics of survey respondents and interview participants are presented in Supplementary Table S1. A total of 178 veterinary staff completed the online survey and 25 stakeholders were interviewed. The majority of the online survey respondents and interview participants were aged between 35–44 years (60%, $n = 103$ and 64%, $n = 16$, respectively). Fifty-three percent of the survey respondents ($n = 92$) and 36% of the interview participants ($n = 9$) were female. In terms of work role, the majority (53%, $n = 83$) of survey respondents were district-level veterinary officers, followed by provincial-level officers (38%, $n = 60$), while 68% of the interview participants were provincial-level officers ($n = 17$) and 4% were district-level officers ($n = 1$). The remainder of the participants (32%, $n = 7$) included central-level officers, and relevant stakeholders from non-governmental organizations, academic or research institutes in Vietnam.

Most (64%, $n = 107$) survey respondents had a bachelor's degree, while 28% ($n = 47$) had a postgraduate degree and 8% ($n = 14$) had a

diploma certificate. Approximately one-third of respondents had been in their current work role for 0–9 years ($n = 63$); 10–12 years ($n = 47$) and ≥ 13 years ($n = 54$), respectively. More than half of the respondents (57%, $n = 102$) had completed any formal or further training in epidemiology. Forty-three percent of these respondents had attended epidemiology workshops ($n = 77$) and 13% had a postgraduate qualification in epidemiology or a field epidemiology training program (FETP) ($n = 23$). With reference to the subregion that survey respondents and interview participants, respectively, were working within, 40% ($n = 66$) of and 52% ($n = 13$), respectively, were from the Red River Delta subregion; 13% ($n = 22$) and 20% ($n = 5$) respectively were from the Northeast subregion; 21% ($n = 35$) and 8% ($n = 2$) respectively were from the Central Highlands and 16% ($n = 26$) and 4% ($n = 1$) respectively were from the Mekong River Delta subregion (Figure 1).

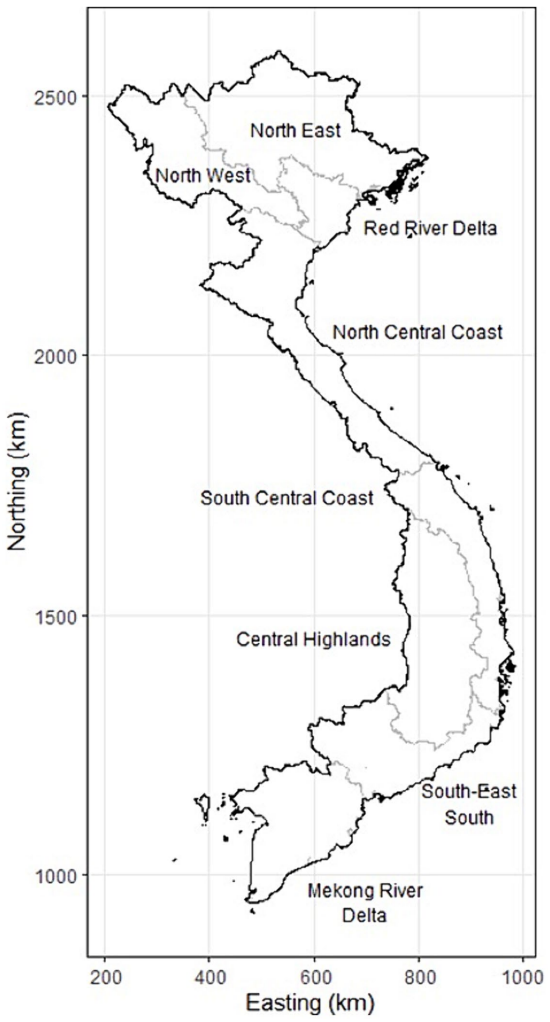

FIGURE 1
Map of the subregions of Vietnam, as described in the text.

3.2 Animal disease surveillance

3.2.1 Data collection

Forty one percent ($n = 71$) of respondents had reported visiting farms and talking with farmers to identify possible cases about once per month. The majority (57%, $n = 97$) had followed up reports of cases from informal sources at least once per month or more than once per month (Table 1).

3.2.2 Laboratory capacity and diagnosis

Participants reported that laboratories at RAHOs and the National Centre for Veterinary Diagnostics (NCVD) generally all met standards (although no reference was made to meeting international standards, like ISO/IEC 17025[1]) (27) and had the capacity for serological, molecular techniques to support case diagnoses. At the provincial and district level, laboratory capacity was limited with only basic diagnostic testing taking place. However, participants noted that samples collected at the provincial level were often sent to RAHOs or the NCVD with rapid turnaround of results.

> *"The National Centre for Veterinary Diagnostics has good testing capacity, producing quick and accurate results, which is in line with clinical diagnoses at localities" (Provincial level veterinary officer).*

3.2.3 Surveillance data analysis

Data analyses were mostly handled by officers at the Sub-DAH and DAH level. Participants noted that there was limited capacity for processing and analyzing raw data, especially at the district and commune levels. Lack of human resources and poor coordination from the commune to the central level were cited as reasons that undermined the effectiveness of disease surveillance.

> *"District veterinary officers only report raw data and are not capable of processing data and identifying risk factors" (Provincial level veterinary officer).*

> *"The grassroot level only collect samples and investigate, analysis is mainly done by DAH, and Sub-DAH" (Provincial level veterinary officer).*

3.2.4 Surveillance systems

Thirty seven percent ($n = 62$) of respondents had never designed a surveillance system; 27% ($n = 45$) had never evaluated the operation and disease reporting components and 30% ($n = 51$) had never identified the strengths, limitations, and gaps of a surveillance system (Table 1).

The Vietnam Animal Health Information System (VAHIS), an online reporting system, was the most frequently cited existing surveillance system. While some participants reported that VAHIS was created to replace paper-based methods of MARD, many others noted that despite its implementation, the paper-based system was still often utilized. The system is accessed only by central (DAH) and provincial level (Sub-DAH) veterinary staff, not district or commune-level staff. Gaps in surveillance are reported to occur as some Sub-DAHs do not enter reports into the system. Further, wildlife disease surveillance, especially in the context of EIDs was highlighted as a crucial surveillance system component that was missing.

1 ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories*, is the international reference for testing and calibration laboratories wanting to demonstrate their capacity to deliver reliable results.

TABLE 1 Animal disease surveillance practices performed by respondents of the online survey in Vietnam ($n = 178$).

Variable	Definition (How often have you done the following in the last year?)	*n* (%)			
		Never	Rarely	About once a month	More than once a month
4.1	Visited farms and talked with farmers to identify possible cases	4 (2.3)	50 (29.1)	71 (41.3)	47 (27.3)
4.2	Followed up reports from informal sources	19 (11.1)	54 (31.8)	59 (34.7)	38 (22.3)
4.3	Reported cases or clusters of cases to the appropriate authorities	11 (6.5)	49 (29.0)	73 (43.2)	36 (21.3)
4.4	Produced a surveillance summary report	22 (12.9)	82 (47.9)	52 (30.4)	15 (8.8)
4.5	Designed a surveillance summary report template that can be used periodically	42 (25.1)	81 (48.5)	27 (16.2)	17 (10.2)
4.6	Designed a surveillance system	62 (36.5)	76 (44.7)	21 (12.4)	11 (6.5)
4.7	Evaluated the operation and disease reporting components of surveillance system	45 (26.6)	82 (48.5)	32 (18.9)	10 (5.9)
4.8	Identified the strengths, limitations, and gaps of a surveillance system	51 (30.2)	81 (47.9)	29 (17.2)	8 (4.7)

> *"Lack of passive surveillance system especially regarding surveillance of wildlife" (Wildlife animal health team leader).*

> *"Some sub-DAHs do not update disease information on VAHIS" (Provincial level veterinary officer).*

3.2.5 Surveillance data reporting

Reporting generally occurred from the commune to district, to provincial and finally to central level and was most frequent during emergency animal disease outbreaks, such as ASF, foot-and-mouth disease (FMD) or highly pathogenic avian influenza (HPAI). Only 21% ($n = 36$) reported cases or clusters of cases to the appropriate authorities more than once per month, and 48% of respondents had rarely produced surveillance summary reports. However, some respondents noted within free-text responses that the frequency of reporting may depend on the area and disease prevention initiatives implemented, which then influences the occurrence of cases. Instant messaging applications were often used to provide daily disease updates, for instance, during outbreaks.

3.2.6 Surveillance training needs

Eighty percent ($n = 138$) of respondents reported a high priority for further training in animal disease surveillance. This was reiterated in the free-text responses of the survey, where respondents noted that training should be provided for veterinary staff at all levels.

3.2.7 Funding

Active surveillance programs for HPAI and FMD were coordinated by the DAH as part of national control programs. Technical and financial support for these programs was reported to often be provided by international organizations, including the Food and Agriculture Organization of the United Nations (FAO) and the US Centre for Disease Control (CDC). Passive surveillance was undertaken for other priority diseases such as rabies, anthrax, *Streptococcus suis* and porcine reproductive and respiratory syndrome. With the exception of HPAI, most participants agreed that the scope of animal disease surveillance in Vietnam was limited due to insufficient and often unequal distribution of funding across provinces. Provinces otherwise depend on local government funding for implementing surveillance programs and it was often noted that there was limited private sector involvement. Insufficient funding limited the scale of sample collection, which raises concerns that the real magnitude of the disease is not realized, and the rate of disease detection is therefore compromised.

> *"Due to funding limitation, the surveillance programs have not been implemented in all provinces/cities in the country." (Central level veterinary officer).*

> *"There is no surveillance program for many dangerous diseases, such as wildlife diseases, dangerous infectious diseases (porcine reproductive and respiratory syndrome, classical swine fever),*

> *zoonoses (anthrax, bovine tuberculosis, brucellosis, leptospirosis)" (Veterinary epidemiologist).*

3.2.8 Predictors of experience in animal disease surveillance

Two variables were statistically significant in the multivariable model of respondent characteristics associated with experience in animal disease surveillance. Veterinary officers who had completed FETP or a postgraduate qualification had greater experience in animal disease surveillance (OR 3.40; 95% CI 1.35, 9.14) than their counterparts without these qualifications. Similarly, those who had attended epidemiology workshops had a higher odds of greater experience (OR 2.64; 95% CI 1.41, 5.01) compared with those who had not attended workshops, after adjusting for postgraduate qualification/FETP (Table 2). There were no interaction variables included in the model. The Hosmer and Lemeshow goodness-of-fit test indicated that the fit of the binary logistic regression model was good ($p = 0.90$).

3.3 Outbreak investigation

3.3.1 Establishing case definitions

When asked how often measures were performed within the last year as part of outbreak investigations, 20% of respondents ($n = 34$) reported having never developed case definitions and 11% ($n = 19$) had never applied case definitions to either animals or farms (Table 3).

3.3.2 Outbreak investigation data collection and analysis

Data collection for disease outbreak investigations commenced at the commune level. Central-level officers visited localities to instruct district and commune-level staff on collecting samples, sanitizing/disinfecting and decontaminating surrounding areas. Thirty-seven percent ($n = 63$) and 19% ($n = 33$) of respondents reported performing clinical examinations and post-mortems for case detection and diagnosis more than once per month, respectively (Table 3). Forty-one percent had rarely collected samples; 44% ($n = 74$) had rarely interpreted lab results and 46% ($n = 77$) had rarely verified an outbreak occurrence. Participants noted that despite an overall lower capacity, there had been an improvement in the skills of district and commune-level veterinary staff, for instance, in data or sample collection and prior to this, only provincial-level staff collected samples. Data analyses were carried out by officers at the Sub-DAH and DAH levels.

3.3.3 Outbreak response

Staff from the Sub-DAH level conducted further investigation of outbreaks with technical support from the RAHOs. Approximately half of the respondents ($n = 79$) had rarely applied preliminary control strategies to contain outbreaks or produced an outbreak report (Table 3). Effective outbreak responses were reported when outbreaks occurred on a smaller scale, however, widespread epidemics were met with challenges due to a lack of sufficiently qualified personnel. Further, when handling emerging infectious diseases or wildlife diseases, respondents noted that they were often limited in their capacity to respond.

> *"Experienced veterinary staff is able to actively respond to emerged diseases, but remain inexperienced in new emerging diseases" (Veterinary academic).*

> *"When wildlife diseases occur, veterinary staff do not well respond" (Wildlife animal health team leader).*

3.3.4 Legislation

Circular No. 07/2016 by MARD on the prevention and control of terrestrial animal diseases was the most frequent protocol cited for disease outbreak investigation. Circular No. 07/2016 contains a list of

TABLE 2 Final multivariable binary logistic regression models for level of experience in animal disease surveillance ($n = 178$) based on questionnaire responses to the online survey conducted in Vietnam.

Variable	None to low (*n*)	Moderate to high (*n*)	OR (95% CI)	*p*-value	Participant experiences
Epidemiology workshops:					"[Curricula] involves constructing outbreak maps, epidemic surveillance methods for infectious diseases, identifying infectious diseases based on symptoms and lesions." *Provincial veterinary officer* "Trainees [selected for training programs] worked at DAH, NCVD, RAHOs, Sub-DAHs, whose responsibilities include disease surveillance, outbreak investigation and response, trainees from institutes and universities were also included." *Senior Technical Coordinator, International Organization*
Did not attend	72	29	Ref	0.002	
Attended	37	40	2.64 (1.41, 5.01)		
Postgraduate qualification/FETP:					
No	101	54	Ref	0.009	
Yes	8	15	3.40 (1.35, 9.14)		

TABLE 3 Outbreak investigation practices performed by respondents of the online survey in Vietnam ($n = 178$).

Variable	Definition (How often have you done the following in the last year?)	*n* (%)			
		Never	Rarely	About once a month	More than once a month
1.1	Clinical examination for case detection and diagnosis	3 (1.8)	43 (25.1)	63 (36.8)	62 (36.3)
1.2	Post-mortem examination for case detection and diagnosis	13 (7.6)	68 (39.8)	57 (33.3)	33 (19.3)
1.3	Developed case definitions to classify animals or farms as cases and non-cases	34 (20.0)	73 (42.9)	48 (28.2)	15 (8.8)
1.4	Applied case definitions to classify animals or farms as cases and non-cases	19 (11.4)	74 (44.3)	49 (29.3)	25 (15.0)
1.5	Verified outbreak occurrence	13 (7.7)	77 (45.8)	49 (29.2)	29 (17.3)
1.6	Trace-forward and backward searches to identify cases	14 (8.2)	83 (48.8)	45 (26.5)	28 (16.5)
1.7	Created an outbreak investigation questionnaire	28 (16.7)	82 (48.8)	43 (25.6)	15 (8.9)
1.8	Collected samples	9 (5.3)	69 (40.8)	53 (31.4)	38 (22.5)
1.9	Created sample submission forms	26 (15.4)	71 (42.0)	50 (29.6)	22 (13.0)
1.10	Used lab submission forms	14 (8.4)	69 (41.3)	54 (32.3)	30 (18.0)
1.11	Transported samples to the lab	18 (10.7)	76 (45.2)	40 (23.8)	34 (20.2)
1.12	Interpreted lab results	40 (23.8)	74 (44.0)	35 (20.8)	19 (11.3)
1.13	Analyzed data from an outbreak by space, time, and animal group	22 (13.1)	95 (56.5)	35 (20.8)	16 (9.5)
1.14	Applied preliminary control strategies to contain the outbreak	17 (10.1)	79 (46.7)	54 (32.0)	19 (11.2)
1.15	Produced an outbreak report	15 (8.9)	75 (44.4)	55 (32.5)	24 (14.2)

diseases of terrestrial animals subject to outbreak declaration, compulsory prophylactic measures, guidance around reporting, diagnosis and inspection and conditions for declaring the end of an outbreak.

3.3.5 Outbreak investigation training needs

Overall, most respondents agreed that while the majority of veterinary staff had experience and/or training in outbreak investigation, the capacity of commune-level veterinary staff was limited. This was reported to be due to a lack of in-depth training opportunities, lack of access to resources and high staff turnover. In communes where outbreaks occurred frequently, veterinary staff had more experience and capacity compared to communes where outbreaks were rare. While veterinary staff at the provincial and district level were reported to receive annual training on investigating disease outbreaks, 80% ($n = 136$) of respondents reported a high priority for further training in outbreak investigation. Free-text responses from the survey reiterated the need for training, particularly for grassroots veterinary officers. Provincial veterinary officers were trained through courses provided by DAH and district-level officers were often sent to participate in training programs coordinated by Sub-DAHs.

> *"At the commune level, the capacity of veterinary staff in outbreak detection, especially new emerging diseases, remains limited" (Veterinary academic).*

> *"In communes where outbreaks occur frequently, commune veterinary staff have a lot of experience, and in communes where outbreaks are rare, veterinary staff have little experience" (Provincial veterinary officer).*

3.3.6 Predictors of experience in outbreak investigation

Only two variables were statistically significant in the multivariable model of respondent characteristics associated with experience in outbreak investigation. Veterinary officers who had

completed FETP or a postgraduate qualification in epidemiology were more likely to have higher levels of experience in outbreak investigation (OR 3.59; 95% CI 1.39, 10.54). Similarly, those who had attended epidemiology workshops were also more likely to have higher experience levels than veterinary officers who had not attended workshops (OR 2.18; 95% CI 1.18, 4.07) (Table 4). There were no interactions included in the model. The Hosmer and Lemeshow goodness-of-fit test indicated that the fit of the binary logistic regression model was good ($p = 0.95$).

4 Discussion

This study was conducted to understand the current capacity of field veterinary staff in Vietnam in animal health surveillance and outbreak investigation, using 'experience level' as a proxy indicator. The findings of this study allow us to identify gaps in competencies that require strengthening and can be used to prioritize training for field veterinary staff in Vietnam. We also explore underlying reasons for these gaps in capacity, such as training opportunities, governance of veterinary services and funding. The findings from this study can be used in conjunction with insights from WOAH's PVS evaluation report, and WHO's Joint External Evaluation (JEE) to provide a greater understanding of the national capacity in veterinary epidemiology.

4.1 Training opportunities

Early detection and response to potential disease threats are essential to protect population health and strengthen health security. The cornerstone of early detection is a strong surveillance system, which requires effective training of personnel and the development of core competencies (28). Our findings show that veterinary officers with formal epidemiology training – specifically, FETP graduates or officers with postgraduate qualifications in epidemiology – were more likely to have a higher level of experience in the core competencies of animal disease surveillance. Similarly, short training programs like 'FETP-Frontline', have shown improvements in local surveillance quality within weeks of initiating training (29). In response to the 2009 H1N1 pandemic, FAO established an FETP for veterinarians (FETPV) in the Southeast Asia region, promoting training that improves animal disease surveillance, control and prevention (30). The Applied Veterinary Epidemiology Training has also been established in Vietnam for field veterinarians to participate. However, in the study, we found only 15% of participants had completed FETP and/or an equivalent postgraduate qualification in epidemiology and the majority were provincial officers, rather than staff from the local level.

Prior qualifications and technical skills have previously been identified as factors contributing toward an effective outbreak investigation (31). Like the level of experience in animal health surveillance, veterinary officers with formal epidemiology training (namely, FETP or postgraduate qualifications in epidemiology) were more likely to have a higher level of experience in outbreak investigation. While there may be adequate capacity among FETP graduates who are generally working at the provincial or central level, this is only a minority of the workforce and a gap appears to exist at the subnational, specifically the district (and likely, commune level), who are generally animal health professionals responding at the frontline. A recent study conducted in Kenya, where the animal health services are also decentralized, found as similar issue of uneven level and intensity of training and resources at the subnational level (32). The need for training and capacity building of staff at the subnational level to effectively manage health challenges at the frontline is of high priority as a collection of quality data at the local level in a timely manner is fundamental to more rapid disease detection, response and containment at the source to prevent the spread (29, 32).

TABLE 4 Final multivariable binary logistic regression models for level of experience in outbreak investigation ($n = 178$), based on questionnaire responses to the online survey conducted in Vietnam.

Variable	None to low (*n*)	Moderate to high	OR (95% CI)	*p*-value	Participant experiences
Epidemiology workshops:					"[Training program curricula involves] training the technical staff on the sampling, investigating and outbreak response skills, coordinating in sharing information and methods of disease report to ensure timely and transparent information from the grassroots up." *Central veterinary officer* "Officers obtain not only certificates but knowledge and experience in outbreak response, that directly helps with their tasks." *Provincial veterinary officer*
Did not attend	62	39	Ref	0.01	
Attended	32	45	2.18 (1.18, 4.07)		
Postgraduate qualification/FETP:					
No	88	67	Ref	0.008	
Yes	6	17	3.59 (1.39, 10.54)		

4.2 Governance of veterinary services

With field staff currently authorized and funded by Sub-DAHs, there is no direct chain of command over field animal health activities by the DAH or direct technical reporting pathway from the field for activities such as surveillance (20). Surveillance and disease control capacity gaps were often identified in commune and/or district-level veterinary staff, who were described as having a limited capacity for processing and analyzing accumulated data due to a lack of in-depth training opportunities, access to resources and high staff turnover.

Vietnam currently lacks a veterinary statutory body to set the minimum standards for veterinarians and para-professionals and regulate the conduct of the veterinary profession (21). Further, the JEE of Vietnam states that there are currently no requirements for veterinarians to be included in continuous education programs for surveillance and control of animal diseases (33). Standardization and registration of veterinary staff will raise skills and knowledge levels to achieve more consistency of the services provided, like surveillance and disease control (21). While decentralized governance structures may partially explain the disparities in capacity between the various levels of veterinary staff, further research is required to establish the underlying cause and magnitude of differences in training opportunities. Future efforts should focus on research into other barriers that might be preventing participation in continuing education, incentivization and training of district and commune-level veterinary staff.

4.3 Sustainable funding

Unequal and insufficient funding from local governments across provinces were reported as barriers to the scope and quality of animal health activities on the field. In terms of surveillance, insufficient funding limited the scale of sample collection, which raises a concern that the real magnitude of the disease is not realized, and the timeliness of disease detection is compromised. Active surveillance programs exist for HPAI (and other diseases such as FMD) as part of national control programs, which receive funding from the central government or international organizations (34) but animal health activities in the provinces are otherwise funded from provincial budgets, due to the decentralized nature of animal health services (20). Public financing for outbreak response is reported to be only available after outbreaks are officially declared, which is suggested to impact outbreak investigations at a sub-national level and increase reliance on donors or personal resources to fund initial investigations (34). The gaps in the chain of command between DAH, sub-DAH, district, and commune levels also limit the level of responsiveness and support for early detection and response to a disease outbreak (20).

In 2003–2006, during the HPAI outbreak, there was a significant investment in the development of animal health capacity, where training on outbreak investigation and epidemiological surveillance was provided in all provinces and districts nationwide, including to veterinary staff at the grassroots level actively engaged in conducting field surveillance in villages (35). Since the emergence of HPAI, laboratory capacity in Vietnam has strengthened after receiving international support, which corroborates with the information provided by participants in the study. However, the need to move away from externally driven, short-term, emergency response type vertical approaches to a more sustainable horizontal approach and long-term strengthening of animal health systems is recognized (36).

Ensuring stable and sustainable financial resources for ongoing activities across provinces appears to be an ongoing issue for veterinary services in Vietnam based on the study findings. While the provision of sufficient and sustainable funding to local governments may be unlikely as a longer-term solution, shared responsibilities and resources through public-private partnerships (PPPs) are proven to deliver sustainable services in the animal health sector. However, participants reported limited private sector involvement when discussing the implementation of surveillance systems in Vietnam. Indonesia's national animal information system, iSIKHNAS, is fully sustained within a PPP between the Indonesian government and a private Indonesian IT company (37). Like Vietnam, Indonesia consists of autonomous provinces. iSIKHNAS provides a reporting facility that connects farmers or district animal health workers with local officials to report illnesses in livestock so they can receive treatment immediately and reduce losses. As a result, there is improved trust between farmers and local Veterinary Services, and better services delivered through the PPP address the needs of the farmers who provide data for national benefit (37, 38). A similar approach could be considered to ensure the long-term sustainability of VAHIS.

4.4 Study strengths and limitations

This study has several strengths and limitations. Outside of the PVS and JEE, there is limited information about the current capacity of field activities of veterinary services in the Asia-Pacific region. The findings from this study can guide the design of veterinary training programs tailored to the local context and adapted to meet the needs and priorities of field veterinarians in Vietnam.

Regarding the methodology used, we recognize that self-completed questionnaires may suffer from recall bias and obsequiousness bias, however the recall period was reduced to 12 months in the online survey to minimize recall bias. Triangulation using the online survey and key informant interviews was also used to contextualize findings and improve validity. We also recognize that knowledge and training do not necessarily equate to the level of experience and other factors like previous experience, skills, capabilities, and work environment should also be considered in future studies. Further, all members of veterinary services are not always required to have the same level of knowledge and experience; instead, this would be based on their specific roles and responsibilities.

Commune-level veterinary staff were not captured by the survey or interviews due to movement restrictions in place during the COVID-19 pandemic limiting participation from their remote duty stations and limited access to technology used for surveys and interviews. Their exclusion limits the representativeness of the sample and should be improved upon in future studies.

5 Conclusion and recommendations

This study identified gaps in knowledge, skills and practices related to animal disease surveillance and outbreak investigation. By identifying the skills that field staff never or rarely participate in, we can highlight the areas that require urgent attention through epidemiology training in surveillance and outbreak investigation. As such, the findings of this study will enable prioritization of training and other capacity-building

activities to further enhance the national capacity of veterinary services in Vietnam. Underlying barriers and causes for existing gaps in capacity, namely unequal skill development and training opportunities between levels of veterinary staff, gaps in the chain of command, and unequal funding between provinces, should be considered as key issues when considering longer-term solutions. Both short and long-term field epidemiology training courses should be coordinated, targeting staff at all levels and in all provinces or districts to improve the delivery of animal health services in the field. Consideration of PPPs could also improve the sustainability of efforts.

APCOVE is a consortium of veterinary epidemiologists established to strengthen field veterinary epidemiology capacity in the Asia Pacific region, working with government animal health authorities and educators to strengthen their existing on-the-job training programs. The results of this study will be used to ensure that training responds to the needs and priorities of the local animal health workforce in Vietnam. Strengthening veterinary services will serve to improve animal and human health outcomes, effectively and sustainably, through enhanced prevention, detection, and response capacity against disease threats and challenges.

Data availability statement

The datasets presented in this article are not readily available because the questionnaire survey form is available within the article Supplementary material. Additional data at the level of individual responses is not available as per confidentiality agreements approved by the Human Research Ethics Committee, University of Sydney. Requests to access the datasets should be directed to ND, navneet.dhand@sydney.edu.au.

Ethics statement

The studies involving humans were approved by Human Research Ethics Committee at the University of Sydney. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin because Verbal consent was provided by each participant before commencing the interview process and audio recording interviews.

Author contributions

AA: Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft. TT: Data curation, Writing – review & editing. PP: Data curation, Writing – review & editing. AG: Data curation, Formal analysis, Methodology, Project administration, Supervision, Writing – review & editing. HT: Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. TH: Methodology, Writing – review & editing. MS: Conceptualization, Methodology, Writing – review & editing. ND: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2024.1410606/full#supplementary-material

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Veterinary support staff knowledge and perceptions of antimicrobial drug use, resistance, and stewardship in the United States

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Antimicrobial drug use (AMU) in veterinary medicine may contribute to antimicrobial resistant (AMR) infections in both animals and people. Efforts to improve AMU in companion animal medicine are underway and should include all members of the veterinary team, including veterinary support staff. Our objective was to describe knowledge and attitudes regarding AMU, AMR, and antimicrobial stewardship (AMS) in companion animal medicine among veterinary support staff professionals in the United States using an anonymous, online questionnaire. Additionally, we sought to explore veterinary support staff perceptions of their role in the antimicrobial drug (AMD) prescribing process. Veterinary technicians, nurses, assistants, client care representatives, and hospital managers ($n = 337$) considered AMR a global concern (83.4%), and 40% reported receiving AMR education from their employer. Few (18.3%) were aware of AMS, with only 6.4% indicating that their clinic had an AMS program. Frequent involvement in the AMD prescribing process was reported (43.4%), but only 19.7% perceived involvement with AMS interventions. Approximately one-third of participants (34.9%) said that advice regarding the need for AMDs was routinely provided by staff to pet owners prior to veterinary consultation. Participants estimated that 82.6% of all AMD prescriptions were filled at the clinic as opposed to an outside pharmacy. Given their direct involvement in the AMD prescribing process and frequent interactions with pet owners, AMS should be emphasized to all veterinary staff. Involving support staff in AMS interventions is necessary to improve AMU in companion animal medicine.

KEYWORDS

antibiotic resistance, antibiotic use, stewardship, veterinary staff, companion animals

Introduction

Globally, antimicrobial resistance (AMR) is a critical animal and public health problem. In the United States alone, antimicrobial resistant pathogens are estimated to complicate three million cases of human illness annually, resulting in 35,000 deaths (1). In companion animal medicine, AMR impacts animal health and welfare due to infections that do not respond to antimicrobial drugs (AMD) (2, 3). The development of AMR has been linked with antimicrobial drug use (AMU) in both people and animals (4). Moreover, a previous human drug-resistant

enteric disease outbreak traced back to puppies has raised questions about how AMU in companion animals contributes to AMR in humans (5, 6). As such, mitigation strategies to reduce AMR in humans and animals require a One Health approach integrated across human, animal, and environmental health sectors (7).

Numerous efforts are underway to promote judicious AMD use principles in veterinary medicine (8, 9). Studies focused on companion animal medicine and AMD prescribing suggest that compliance with judicious AMU principles could be improved through the implementation of antimicrobial stewardship (AMS) programs at the clinic level (10, 11). Furthermore, the results from a nationwide survey indicate that veterinarians think support staff training on AMR and AMS can improve AMU in companion animal medicine (12). Veterinary technicians/nurses, assistants, client care representatives, hospital managers and other support staff play a vital role in the everyday operations of a veterinary clinic. Given the team approach to daily clinical operations and their frequent interactions with pet owners, successful AMS interventions need to involve all staff members.

The decision to prescribe an AMD is a complex medical and social process that includes multiple stakeholders, including veterinarians, pets, pet owners, and veterinary support staff. To better understand the dynamics of AMD prescribing and to identify opportunities for improved AMU, all stakeholders need to be considered. However, knowledge of AMU, AMR, and AMS among veterinary support staff, along with perceptions of their role within the AMD prescribing process, has not been assessed. The purpose of this study was (1) to explore veterinary support staff knowledge and attitudes regarding AMU, AMR, and AMS in companion animal medicine, and (2) to assess veterinary support staff perceptions of their role in the AMD prescribing process.

Materials and methods

We surveyed veterinary support staff who worked in companion animal practice in the United States, using an anonymous, open, online survey designed using Qualtrics™ software. For this study, veterinary support staff included technicians, nurses, other clinic staff (excluding veterinarians), veterinary technician or assistant students, groomers, client care representatives (i.e., front desk staff), and hospital managers. The survey included questions on participant demographics (e.g., veterinary support staff role, years in practice, and location of practice), knowledge and attitudes of AMU, AMR and AMS programs, and perceptions of involvement in the AMD prescription process (Supplementary material S1). Ten questions used a five-point Likert scale, with response options ranging from strongly disagree, disagree, neither agree nor disagree, agree, strongly agree. "Do not know" and "Not applicable" response options were also included. Four additional questions used a four-point scale with options "Yes", "No", "Unsure", and "Prefer not to answer". Finally, using a sliding scale from zero to 100 %, the last question asked participants to quantify the percent of AMD prescriptions that were filled outside of the respondent's hospital.

The survey was piloted with 10 veterinary science professionals (i.e., veterinarians, veterinary technicians, and veterinary assistants) with feedback being used to revise the tool prior to its nationwide distribution. The survey was available from February 1, 2021, to April 30, 2021, and a convenience sampling approach was used to maximize the number of responses from veterinary support staff professionals across the United States. State veterinary technician associations in 41 states were contacted via email or social media and asked to distribute the survey link to their members by email, electronic newsletter, or social media post. In the nine states without a veterinary technician association, we contacted the state's veterinary medicine association for assistance in distributing the survey. Additionally, national associations for veterinary technicians and canine groomers, veterinary social media influencers, and educational publications were engaged to disseminate the survey link. Support staff were eligible to participate if they worked in a veterinary setting or were currently in a veterinary training program based in the United States. Participants self-selected into the study by opening the common distributed survey link and acknowledged informed consent to participate prior to completing the survey. No personal or identifying information was collected. The study protocol and survey instrument were reviewed by the Colorado Multiple Institutional Review Board (COMIRB) and designated as "Not Human Subject Research". All methods and procedures were administered in compliance with applicable guidelines and regulations.

Demographic characteristics of participants were analyzed descriptively. For analysis purposes, participants were classified into three categories according to their response to the question about veterinary support staff position type: (1) veterinary technician or nurse, (2) veterinary technician student or intern working in a clinic environment, and (3) other support staff, such as hospital administrators or veterinary assistants. When the response to the role question was complete, surveys with partial responses to the perceptions and knowledge items were retained in the final dataset to maximize the sample size for each question. Differences in responses to Likert scale and yes/no questions by role type were examined using a Pearson χ^2 test (or Fisher's Exact test when less than five responses) with a p-value of <0.05 considered statistically significant. All analyses were performed after the survey period closed using SAS® software version 9.4 (SAS Institute, Cary, NC, United States).

Results

A total of 367 surveys were returned over the study period. Of these, 30 were excluded because the participant did not work in the veterinary field ($n=11$), did not report a role ($n=5$), reported an ineligible role (e.g., veterinarian) ($n=8$), did not work in the United States ($n=4$), or did not consent to complete the survey ($n=2$). Of the 337 participants included in the study, most (60%) self-described as a veterinary technician or nurse, followed by technician student or intern (23%) (Table 1). Most worked in an urban (27%; 90/344) or suburban (47%; 156/344) setting. All four U.S. census regions were represented, although most participants were from the South (38%; 122/321) or West (29%; 92/321). Over half (54%; 178/334) of the participants had less than 5 years of experience. Of those who reported working as a "veterinary technician," "veterinary nurse," or "hospital management," 84% (202/241) had received formal training for their position, such as completing a veterinary technician or veterinary assistant program.

Most participants agreed that they were familiar with AMR (86.5%; 270/312) and that AMR is a global concern (83.4%; 257/308); however, only 32.8% (102/311) indicated that they were concerned about AMR at their clinic or hospital (Table 2). While agreement did not differ significantly between roles, students and interns working in a clinic environment were less likely to agree with these statements when compared with technicians/nurses and other support staff.

TABLE 1 Descriptive characteristics of study participants in a convenience sample of small animal clinics/hospitals support staff in the US using an online survey tool, 2021 ($n = 337$).

Characteristic	*n* (%, standard error (SE))
Role (n = 337)	
Technician or nurse	203 (60, 2.67)
Student or intern	77 (23, 2.29)
Technician assistant	39 (12, 1.77)
Other support	18 (5, 1.18)
Location type (n = 334)	
Urban	90 (27, 2.43)
Suburban	156 (47, 2.73)
Rural	63 (19. 2.15)
Unsure	22 (7, 1.40)
Prefer not to answer	3 (1, 0.54)
Census region (n = 321)	
Northeast	50 (16, 2.04)
Midwest	57 (18, 2.14)
South	122 (38, 2.71)
West	92 (29, 2.53)
Years of experience (n = 334)	
< 1	42 (13, 1.84)
1–5	136 (41, 2.69)
6–10	53 (16, 2.01)
11–15	28 (8, 1.48)
> 15	75 (22, 2.26)
Any formal training (n = 241)[a]	202 (84, 2.36)

[a]Formal training such as completing a veterinary technician program, veterinary assistant program, or other.

Approximately 40% (125/298) of participants reported receiving AMD-specific education from their employer (technician/nurse 44.4%, student/intern 35.9%, other support staff 40.4%, $p = 0.008$). However, only 18.3% (57/311) strongly agreed or agreed that they are familiar with AMS programs (technician/nurse 22.8%, student/intern 11.6%, and other support staff 10.2%, p-value = 0.03). Additionally, few (6.4%; 19/298) participants indicated their clinic or hospital has an AMS program (Table 2).

Participants frequently (43.4%; 129/298) reported being involved in prescribing practices at their facility (technician/nurse 50.8%, student/intern 25.0%, other support staff 38.3%, $p = 0.001$). Most agreed that they are confident in educating clients about AMD use in pets (77.2%; 240/311) (technician/nurse 85.5%, student/intern 55.1%, other support staff 75.5%, $p < 0.0001$) and that they are comfortable collaborating with veterinarians and other staff (61.8%; 186/301). However, only 19.7% (59/300) agreed that they have a role in AMS interventions at their clinic or hospital (technician/nurse 24.1%, student/intern 9.2%, other support staff 16.7%, $p = 0.03$), and only 30.2% (91/301) agreed that veterinarians listen to their input when prescribing AMDs (technician/nurse 35.6%, student/intern 15.4%, other support staff 29.2%, $p = 0.009$) (Table 2). Only 26.2% (78/298) agreed that they have an impact on AMD prescribing during a veterinary appointment.

Specific to AMD prescribing practices within their hospitals, roughly one-third of participants (34.9%; 104/298) reported that advice about whether a pet needs antibiotics is routinely given to pet owners over the telephone at the time a client makes an appointment for their pet. Across all participants, it was estimated that 82.6% of all antibiotic prescriptions recommended by a veterinarian at the time of examination are filled in the clinic or hospital.

Discussion

The mitigation of AMR in companion animal medicine is a priority for both animal and human health, and a team approach is instrumental for stewardship interventions to be successful. There is a need to educate veterinary support staff about judicious AMD use in companion animal medicine and involve them in clinical AMS programs. Our study found that veterinary support staff are aware of the problem of AMR but are less aware of AMS principles within companion animal medicine. Regarding the AMD prescription process, staff felt comfortable with AMD client education and veterinarian collaboration but often felt they had little impact on the prescribing process nor had a role in AMS interventions.

Several discrepancies regarding veterinary support staff AMR knowledge and perceptions were noted in this study. First, many support staff professionals were concerned with AMR on a global scale but did not perceive it as a problem at their facility. While no previous studies have assessed AMR knowledge and perceptions of veterinary support staff, findings in human medicine have noted a similar discrepancy between AMR concern and the perceived contribution of their facility to the problem (13–15). A second discrepancy found in the current study was that few surveyed veterinary support staff were familiar with AMS principles in veterinary medicine despite recognizing AMR as a problem and receiving education from their employer that focused on the topic of AMU. Similar findings of relatively higher AMR awareness when compared to AMS knowledge have been noted in previous human medicine studies (13, 14, 16). In contrast, a study of Australian veterinary students noted good understanding of both AMR and AMS, but that there were differences between what they were taught in the classroom versus in clinical training (17). It is unknown whether the lack of AMS awareness is due to the absence of veterinary support staff involvement in AMS programs, differences in AMS principles taught formally versus on-the-job training, or the result of few veterinary facilities implementing AMS programs.

Participants identifying as a veterinary technician or nurse agreed that they played a role in AMS interventions more often than they agreed that they were aware of AMS principles in general. This discrepant finding may indicate that veterinary technicians feel they are performing AMS activities as part of their job but do not fully understand the principles behind those tasks. This finding, along with the contradictions noted above, demonstrates a need to educate support staff about the threat of AMR at the clinic level and to increase awareness of veterinary AMS program principles. Previous assessments noted an improvement in knowledge of AMR and AMS among human healthcare professionals after formal training programs (18, 19). Furthermore, there have been calls in human medicine to make AMS education for support staff a priority (20). Based on data gathered in this assessment, a similar approach to educating veterinary support staff about AMR and AMS standards should be pursued to enhance the success of AMS programs.

The results describing involvement in the AMD prescription process demonstrate that support staff are relatively comfortable educating clients about AMU and confident in collaborating with veterinarian

TABLE 2 Veterinary support staff knowledge and perceptions of antimicrobial use, resistance, and stewardship by role in a convenience sample of US small animal clinics/hospitals using an online survey tool (2021).

	Agree/strongly agree or yes, *n* (%, SE)				*p*-value
	Technician/nurse[b]	Student/intern[b]	Other support[b]	Overall[b]	
Antimicrobial resistance statements					
I am familiar with antibiotic resistance (*n* = 312)	172 (88.7, 2.27)	54 (78.3, 4.96)	44 (89.8, 4.32)	270 (86.5, 1.93)	0.072
AMR is a global concern (*n* = 308)	160 (84.2, 2.64)	54 (78.3, 4.96)	43 (87.8, 4.67)	257 (83.4, 2.12)	0.353
I am concerned about AMR at my clinic/hospital (*n* = 311)	65 (33.7, 3.40)	18 (26.1, 5.28)	19 (38.8, 6.96)	102 (32.8, 2.66)	0.321
I have received education focused on antibiotic use (i.e., from your employer) (*n* = 298)[a]	83 (44.4, 3.63)	23 (35.9, 5.99)	19 (40.4, 7.15)	125 (42.0, 2.86)	0.496
Antimicrobial stewardship awareness statements					
I am familiar with antibiotic stewardship programs (*n* = 311)	44 (22.8, 3.01)	8 (11.6, 3.85)	5 (10.2, 4.32)	57 (18.3, 2.19)	0.033
My clinic/hospital has an antibiotic stewardship program (*n* = 298)[a]	13 (7.0, 1.87)	5 (7.8, 3.35)	1 (2.1, 3.53)	19 (6.4, 1.42)	0.433
Antimicrobial drug prescribing statements					
I am confident educating clients about antibiotic use in their pets (*n* = 311)	165 (85.5, 2.53)	38 (55.1, 5.98)	37 (75.5, 6.14)	240 (77.2, 2.38)	<0.0001
I am comfortable collaborating with veterinarians and other staff regarding antibiotic use (*n* = 301)	118 (62.8, 3.52)	38 (58.5, 6.11)	30 (62.5, 6.98)	186 (61.8, 2.80)	0.822
I have a role in antibiotic stewardship interventions at my clinic/hospital (*n* = 300)	45 (24.1, 3.12)	6 (9.2, 3.58)	8 (16.7, 5.38)	59 (19.7, 2.30)	0.030
Veterinarians listen to my input when prescribing antibiotics (*n* = 301)	67 (35.6, 3.49)	10 (15.4, 4.47)	14 (29.2, 6.56)	91 (30.2, 2.64)	0.009
I have an impact on whether an antibiotic is prescribed to an animal during a veterinary visit (*n* = 298)	50 (27.0, 3.26)	14 (21.5, 5.09)	14 (29.2, 6.56)	78 (26.2, 2.54)	0.602
I am involved in the antibiotic prescription process at my clinic/hospital (*n* = 298)[a]	95 (50.8, 3.65)	16 (25.0, 5.41)	18 (38.3, 7.09)	129 (43.3, 2.87)	0.001
Advice about whether a pet needs antibiotics is routinely given to a client at the time of making an appointment at my clinic/hospital (*n* = 298)[a]	57 (30.5, 3.36)	26 (40.6, 6.13)	21 (44.7, 7.25)	104 (34.9, 2.76)	0.106

[a]Question response framework was Yes/No/Unsure/Prefer Not to Answer, 'yes' answers are included in table.
[b]Number of responses varied for each question by role and overall.

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colleagues but feel they have little impact on the AMD decision-making process. At the same time, participants indicated that advice about a pet's need for AMDs is routinely given to clients prior to the pet being examined by a veterinarian. This may impact client expectations about receiving an AMD for their pet even before a veterinarian has had the opportunity to evaluate a pet's condition and need for a prescription. We noted that most AMD prescriptions are filled in the clinic as opposed to an outside pharmacy, indicating that the AMD prescription process typically takes place in the absence of other external stakeholders (e.g., pharmacists). These results suggest that there are natural opportunities for support staff to influence judicious AMU both before a veterinary consultation and within hospital walls. The inclusion of all professional staff in the AMD prescription process and AMS activities is emphasized in the human medical field, as studies have concluded that nurses possess the necessary skills to be part of team-based stewardship solutions (21, 22). Nurses in human medicine are also seen as having a critical liaison role between stakeholders (i.e., physicians and patients) in the AMD prescription decision-making process (23). Medical support staff perform numerous functions that are necessary for prudent AMU, including patient communication, drug administration, and collaborating with physicians (20). Additionally, it has been previously noted that human medical staff perceive that they play an important role in AMS activities (24). Given that veterinary support staff perform several functions that can support clinical AMS and are comfortable educating clients about AMD use in their pets, these professionals should always be considered when developing and implementing AMS programs. This involvement may come in the form of delivering continuing education, enhancing collaboration between staff and veterinarians, and assigning AMS roles that match individual support staff member strengths. Further information is needed, however, on the barriers that prevent the formal inclusion of support staff in the AMD prescription process and AMS programs.

This study had several limitations. First, this was a cross-sectional survey, which provides only a snapshot of current attitudes and perceptions among veterinary support staff professionals. Additionally, participants self-selected into the study and may have been different than the target population, resulting in possible selection bias, which could potentially limit the generalizability of the study's findings. Based on experience and background, participants may have interpreted survey questions differently than intended, potentially introducing an information bias. Next, as we did not collect information on clinic location to protect participant identity, we were unable to account for possible correlations in survey responses clustered by facility. This limitation has the potential to bias estimates away from true null associations, making them appear more significant than they are in the presence of clustering. Finally, only a small number of participants indicated that they worked in the "other" role (i.e., client care representative, groomer, or hospital manager). While these individuals often have less direct contact in the medical care of animals, they may still have an important role in the AMD prescription process. With a low response from this role, it is difficult to define their knowledge of AMU use in companion animals and their perception of involvement in the AMD prescribing process.

Conclusion

This study addresses a critical knowledge gap within the companion animal AMD prescription process by surveying veterinary support staff, a population that has not been extensively considered in previous research. Veterinary support staff have variable knowledge of AMR and AMS in companion animal medicine, resulting in several discrepancies that demonstrate the need for further education among these professionals. As participants reported a high level of confidence when educating pet owners and collaborating with veterinarians but perceived a limited impact on the AMD prescription process, clinical AMS plans should explicitly incorporate veterinary support staff and assign stewardship tasks that match individual strengths. By emphasizing AMS principles among veterinary support staff and encouraging them to advocate for judicious AMD use, these professionals can play a significant role in improving AMU in companion animal medicine.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The survey was administered anonymously, and no personal information was collected. The study protocol and survey tool were reviewed by the Colorado Multiple Institution Review Board (COMIRB) and found to be "Not Human Subject Research". Participants self-selected into the study and acknowledged informed consent prior to beginning the survey.

Author contributions

LG-S: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. DT: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Writing – original draft, Writing – review & editing. ESW: Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2024.1401290/full#supplementary-material

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The role of syndromic knowledge in Ethiopian veterinarians' treatment of cattle

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Veterinarians play a significant role in the treatment and prevention of livestock diseases at the farm level, safeguarding public health and ensuring food safety. In sub-Saharan Africa, access to quality veterinary services is a major challenge for livestock farmers due to the low number of publicly employed veterinarians, underfunding and privatisation of veterinary services. Low investment in veterinary services and infrastructure, including a lack of laboratories for diagnosis, has made veterinarians rely on their experience and knowledge of cattle disease symptoms developed over years of practice to diagnose and treat cattle diseases. A cross-sectional survey using a role-play approach was used to collect data on knowledge regarding cattle diseases among veterinarians in veterinary clinics and private practices in Addis Ababa, Oromia and Adama regions in Ethiopia. Veterinarians were given a number of disease scenarios based on "fictive disease symptoms" that are commonly manifested in a sick cow and asked to identify the disease what personal biosecurity they would use, diagnostic tests they would perform, treatments they would prescribe, treatment costs, and additional services and inputs they would recommend to the farmer. The results show that veterinarians could identify endemic cattle diseases through symptoms. The majority of veterinarians did not find it important to report notifiable diseases, a behaviour which could hamper disease surveillance and outbreak response. The advice and services the veterinarians said they would offer and recommend to farmers included improvement in feeding, vaccination, use of artificial insemination, and adoption of farm biosecurity measures that can reduce disease prevalence, and improve food safety, animal health and welfare. Low use of personal protective equipment and other protective biosecurity measures among veterinarians could expose them to zoonotic diseases. The study concludes that there is a need for increased funding for continuous training, improved access to animal health-related information, and investment in infrastructure such as laboratories to enable veterinarians to deliver quality animal health services.

KEYWORDS

animal health services, cattle diseases, disease surveillance, zoonoses, biosecurity practices, one health, herd health management, dairy cattle

Introduction

Veterinarians play an important role in the treatment and prevention of livestock diseases at the farm level (1). Moreover, they safeguard public health and serve as the first line of defence, preventing zoonotic diseases from spilling over into the human population (2). Many endemic cattle diseases are zoonoses and have a dual impact on both human health and livestock production in low-and middle-income countries (LMICs) such as countries in East Africa (3). Therefore, treating and preventing these diseases could alleviate poverty and reduce the health burden that disproportionately affects poor and marginalised populations (3, 4). Compared to developed countries, veterinary education, and animal health services in sub-Saharan Africa still lag behind in terms of human resources, funding and infrastructure (5, 6). Veterinarians in LMICs operate in resource-constrained environments that hinder their ability to contribute to the improvement of public health and food security (7). Although veterinarians in East Africa are resource-constrained, they play an important role in livestock production and safeguarding community livelihoods through the prevention and control of animal diseases (8).

Veterinary training curricula prepare veterinarians to recognise and initiate efficient animal disease control, apply effective treatment of diseased animals, enhance animal welfare, and safeguard human health (9). Veterinarians are trained and qualified to recognise livestock diseases through symptoms and laboratory diagnosis and to provide the correct treatment (1, 2). Although the number of veterinary schools and faculties has grown across Africa, leading to more veterinarians graduating and joining the workforce, the growth in student enrolment has not been matched with increased resources and infrastructure—such as enough teachers, classrooms and laboratories—which could compromise the quality of education and training (5, 10). Additionally, there is a need for continuous training of veterinarians on new emerging and re-emerging diseases and their new treatments as a way of improving the quality and preparedness of animal health services (4).

Veterinarians are themselves exposed to zoonotic diseases that can cause morbidity and mortality in their day-to-day occupational activities (11). However, veterinarians are trained and advised to strictly comply with biosecurity measures [also referred to as infection control practices (ICPs) which include the use of appropriate personal protective equipment (PPE) such as the use of gloves, masks gowns and boots] to protect themselves, their staff, and their clients, and to stop the spread of diseases or infections from one person, animal, or place, to others (12, 13). As there is a lack of studies investigating veterinarians' adoption of biosecurity measures in LMICs, particularly in sub-Saharan Africa, this study aims to explore the use of ICPs by veterinarians in resource-poor settings (13).

There are numerous endemic livestock diseases in East Africa but access to quality veterinary services is a major challenge (14–16). Veterinarian-to-farmer ratios are low in these countries due to underfunding of veterinary services and privatisation necessitated by structural adjustment programmes of the early 1990s (7, 17). In East Africa, veterinarians are constrained by a lack of resources such as laboratory infrastructure and rely often on syndromic knowledge for disease diagnosis and treatment (17). This knowledge of typical symptoms characteristic of a specific disease has been developed through experience and years of practice treating endemic livestock diseases (18, 19). The knowledge is particularly crucial in resource-poor settings, such as in developing East African countries, where diagnostic laboratories are often absent (7, 19). Veterinarians play an important role in disease surveillance through their disease reporting and treatment of livestock at the farm level (7, 18, 19). However, the lack of resources hampers coordination between veterinary services and other relevant authorities leading to challenges in ensuring good disease management at the farm level and food safety from "stable to table" (8, 20). Furthermore, the lack of studies and evidence on the quality of veterinary services offered to farmers in East Africa hinders the improvement of veterinary services (21).

Improving animal health in East Africa could lead to the achievement of sustainable livelihoods and food security (3, 7, 17). Veterinarians could advise farmers regarding the on-farm adoption of biosecurity measures that can improve animal health, welfare and food safety (12). Additionally, veterinarians have an important role to play in the mitigation of antimicrobial resistance (AMR) by advising and encouraging farmers to adopt biosecurity and improve animal welfare, reducing infectious diseases, and antimicrobial stewardship (2, 22), the latter often referred to as an effort to measure and improve how antibiotic drugs are prescribed.

This study focuses on Ethiopia as a case study for several reasons. First, the country has one of the largest cattle populations in East Africa (23, 24). Therefore, it is urgent to prevent and treat livestock diseases to improve animal welfare and food safety and quality (4, 20, 24–29). Secondly, the availability, accessibility, and quality of animal health services is still a major challenge in Ethiopia (7, 19). The government-funded animal health systems that operate at local administrative levels known as "Kebele" are chronically underfunded and understaffed (19) These clinics lack laboratory and diagnostic facilities, and often the necessary medicines, to provide quality animal health services (7, 19). As veterinarians in the public animal health system often lack access to laboratory and diagnostic tools, this makes their syndromic knowledge of common diseases particularly important for disease diagnosis and treatment. However, the lack of supporting diagnostic tools has the potential to lead to wrong diagnosis and inappropriate use of antibiotics, which subsequently can contribute to the development of AMR among bacterial disease agents (19, 20, 22). Therefore, the main objective of this study was to explore veterinarians' knowledge of common animal diseases, their treatment practices, the cost of treatment, their use of personal biosecurity measures, and their sources of information regarding diseases and treatment of animals in Ethiopia.

Methodology

Study area

The study was conducted between September and November 2021 in public and private veterinary clinic practices in Addis Ababa and its surrounding peri-urban areas (including Kaliti, Bole, and Kolfte), in Oromia (including Sendafa, Sebeta, Bishoftu, and Holeta towns), and around Adama town. The study areas were chosen for a number of reasons. First, they are important livestock production areas that supply milk and meat products to the fast-growing population. Second, livestock production is an important livelihood source, especially for smallholder farmers who dominate livestock

production in the urban, peri-urban and rural areas in central Ethiopia (30, 31). A third reason was that livestock production by smallholder farmers faces the challenge of animal diseases endemic in Ethiopia (7). Finally, getting access to animal health services is a challenge for smallholder farmers in Ethiopia and particularly a problem in urban areas where urbanisation, climate change, and intensified livestock production are taking place (30–32).

Questionnaire design

This study used a role-play approach to collect data. A survey questionnaire was designed based on an extensive literature review of the common cattle diseases in Ethiopia and the description of their most common symptoms (24, 27, 33–37). A rapid participatory rural appraisal (PRA) was conducted with veterinarians and researchers to identify cattle diseases of economic and public health importance. PRA involved visiting four animal health clinics in Addis Ababa and Oromia regions and Addis Ababa University College of Veterinary Sciences and discussing with veterinarians and researchers the important dairy cattle diseases in Ethiopia particularly in urban and peri-urban areas and the disease symptoms exhibited in sick cows.

The diseases selected for the survey (after the literature review and the PRA exercise) included brucellosis, bovine tuberculosis (bovine TB), mastitis, milk fever (calcium deficiency and hypocalcaemia), foot and mouth disease (FMD), lumpy skin disease (LSD), anthrax, swollen leg, abscesses and lameness, blackleg, fasciolosis and similar endoparasites, trypanosomiasis, and pasteurellosis. For each disease, a scenario was created that included a set of characteristic symptoms that are commonly manifested in a sick cow. In the questionnaire role-playing game, in each of the scenarios, the veterinarian was asked to treat the cases like a real livestock disease case and identify:

1) The disease.
2) What personal biosecurity measures they would take while examining the animal?
3) Whether they would conduct diagnostic tests before treatment.
4) What treatment they will recommend.
5) What would be the cost of treatment?
6) What additional services and inputs they would recommend to the farmer.
7) What would be the cost of the recommended inputs or services?
8) Whether they would report the disease to the authorities.
9) Their sources of information regarding diseases and treatment.

Recruitment of veterinarians and questionnaire administration

Practising veterinarians were identified and sampled through judgmental non-probabilistic purposive and snowballing techniques due to a lack of information on the number of practicing veterinarians in the study area. The lead researcher relied on referrals from accessible practising veterinarians as getting government records was difficult, particularly personal information due to the civil war in the north which limited what could be shared by government institutions. The researchers therefore interviewed the veterinarians who were present and working in animal health clinics that were visited by the research team during the study period. Given the prevailing COVID-19 travel restrictions and war in Ethiopia, the researchers could only visit clinics in specific areas of Addis Ababa and Oromia.

The inclusion criteria were, (i) should be practising veterinarians either in public or private practice, (ii) willing to voluntarily participate in the study, and (iii) working on ruminants and other animals important for the food chain. Veterinarians were briefed on the study questionnaire, that their participation in the study was voluntary, and that confidentiality would be maintained before informed consent was obtained. The questionnaire was printed, and the veterinarians could fill in and add extra notes on the pages for each disease scenario. The questionnaire took 50–70 min to complete. The research had Ethical clearance from the University College London Research Ethics Committee (UCL-REC) approval number 19867/001 and the Armauer Hansen Research Institute (AHRI) and ALERT hospital AHRI/ALERT Ethics Review Committee (AAERC) approval (Protocol number PO-(46/14)).

Participant observation and informal discussions data collection

Additionally, participant observation and informal discussions were conducted in six animal clinics in Addis Ababa, Adama and Oromia region at the kebele level to observe the issues covered in the questionnaire including the use of PPE, use of ICPs such as segregation of sick animals, the availability of diagnostic equipment and laboratories and treatment of livestock. Participant observations provided additional information allowed for data triangulation and eliminated the bias associated with self-reporting. These participant observations were recorded pictures by the lead author with prior consent from the veterinarians and also summarised as field notes. In each of the clinics, informal discussions were undertaken with one or two veterinarians in the animal clinics and covered issues around staffing, funding, availability of diagnostic laboratories, availability of PPE, quarantine and segregation facilities, and availability of drugs and livestock. In total eight veterinarians were engaged in the informal discussions. These informal discussions were recorded by the lead author with the consent of the veterinarians and were also summarised as field notes.

Data management and analysis

The questionnaire data were entered into an Excel sheet and cleaned. The data were analysed for descriptive statistics including means and proportions using R statistical software. Tests were also undertaken to check for differences based on age, gender or year of graduation.

Thematic content analysis was undertaken on the informal discussions' transcripts and the fieldnotes data. The analysis involved first familiarising with the data through an initial reading of the transcripts. Subsequently, the data was coded into major themes and then grouped into categories of similar ideas. Finally, ad-verbatim quotes were selected to contextualise the major findings.

Finally, the statistical results were compared with the informal discussions, participant observations and pictures collected to check for consistency and also to minimise self-reporting bias, e.g., people

reporting they used PPE while that may not be true from participant observations.

Results

Demographic characteristics of respondents

Table 1 provides the demographic characteristics of the veterinarians who participated in the study. In total 48 veterinarians took part in the questionnaire survey; 47 had Doctor of Veterinary Medicine (DVM) or BSc in Veterinary Science degrees, while one had a BSc in Animal Health degree. The majority of the respondents were male and worked in the government-funded sector. The age profiles of both men and female veterinarians were similar and the majority of the participants graduated after the year 2000.

Syndromic cattle diseases knowledge

Table 2 summarises the veterinarians' knowledge regarding 12 major cattle diseases in Ethiopia. There were no significant differences within the group based on age, gender or year of graduation. The majority of veterinarians correctly identified eight of the 12 different cattle disease scenarios based on the provided characteristic symptoms. However, reversely, only a minority was able to correctly identify pasteurellosis and trypanosomiasis, two diseases which are not common in the highlands of central Ethiopia. Instead, those who did not know frequently reported pasteurellosis as contagious bovine pleuropneumonia (CBPP) and trypanosomiasis as malignant catarrhal fever.

The number of veterinarians who were willing to notify authorities about the notifiable diseases was low with less than 50% of veterinarians ready to notify most diseases, except for anthrax and LSD and swollen legs and abscesses, where 65% ($n = 31$), 60% ($n = 29$) and 71% ($n = 34$) would report, respectively, (Table 2). Veterinarians reported that it was a mandatory requirement to file weekly reports on all the cases, they had dealt with at the animal clinic. Livestock reporting was a requirement for an animal health information system which is meant to ensure Ethiopia has the surveillance capacity to monitor and control important livestock diseases.

In the case of anthrax, the majority of veterinarians recommended that the carcass of the dead animal should not be opened. They also suggested that such carcasses should be handled with appropriate personal protective equipment (PPE) (for example use of gloves, masks gowns and boots) and it should be burned, and the affected cattle shed disinfected. However, two participants suggested that live cattle suffering from anthrax diagnosed through symptoms should be treated with penicillin or other antibiotics. There was a consensus that sick animals should be isolated from healthy ones. In the case of bovine TB, although the majority said they would offer sick cattle antibiotics, only four suggested they would advise the farmers to not consume the milk or meat from the TB-infected cattle. The majority of the veterinarians (70.8%) suggested that they would advise the farmer to isolate bovine TB-infected cattle and/or cull them due to food safety risks associated with meat and milk consumption and the risk of disease transmission to healthy cattle.

TABLE 1 Demographic characteristics of the participant veterinarians ($n = 48$).

		% (n)
Gender	Female	19 (9)
	Male	81 (39)
Mean age (in years)	Both genders	35 ± 10 years
	Female	34 ± 9 years
	Male	36 ± 10 years
Type of employment	Public veterinary clinic	95.8 (46)
	Private veterinary practice	4.2 (2)
Veterinary experience (in years)	Both genders	12 ± 10 years
	Female	11 ± 8 years
	Male	12 ± 11 years
University graduation year	1970s	8.3 (4)
	1980s	4.2 (2)
	1990s	12.5 (6)
	2000s	39.6 (19)
	2010s	35.4 (17)

Treatments

Table 3 shows the various treatment options mentioned by the veterinarians for the treatment of the diseases, compared to the recommendations of the World Organisation for Animal Health: Home – WOAH (formerly, Office International des Epizooties-OIE). The majority of veterinarians recommended using antibiotics for the majority of the diseases.

Other recommendations and animal health advice to farmers

Table 4 presents the additional services, inputs, and advice that participating veterinarians said they would recommend to farmers. The veterinarians said they would provide advice and recommend measures on food safety, biosecurity measures, animal welfare, livestock feeding and farm sanitation and hygiene. These recommendations included also inputs such as vitamins, deworming, vaccinations, and artificial inseminations (AI). The cost of these inputs was rated at 100–550 ETB for multivitamins, 100–2000 ETB for different vaccinations, and 200–500 ETB for AI.

Adoption of biosecurity measures by veterinarians

Table 5 presents the personal biosecurity measures that would be adopted by veterinarians while handling cattle sick with various diseases. There were no significant differences within the group based on age, gender or year of graduation. There was low use of PPE by veterinarians to protect themselves against occupational risks, particularly notable in the case of zoonotic diseases such as bovine

TABLE 2 Knowledge of diseases, notification, testing and treatment practices ($N = 48$).

Disease	Correct disease identification % (*n*)	Would notify about the disease % (*n*)	Would treat against the disease % (*n*)	Test before treatment % (*n*)
Brucellosis	100 (48)	33.3 (16)	66.7 (32)	33.3 (16)
Bovine tuberculosis (TB)	79.2 (38)	39.6 (19)	62.5 (30)	29.2 (14)
Mastitis	97.9 (47)	35.4 (17)	97.9 (47)	47.9 (23)
Milk fever (hypocalcaemia)	87.5 (42)	33.3 (16)	95.8 (46)	2.1 (1)
Foot and mouth disease (FMD)	97.9 (47)	18.8 (9)	75.0 (36)	14.6 (7)
Lumpy skin disease (LSD)	81.3 (39)	60.4 (29)	85.4 (41)	8.3 (4)
Anthrax	100 (48)	64.6 (31)	4.2 (2)	–
Swollen legs, abscesses, and lameness	45.8 (22)	70.8 (34)	87.2 (41)	2.1 (1)
Blackleg	68.8 (33)	33.3 (16)	100 (48)	16.7 (8)
Fasciolosis and other endoparasites	85.4 (41)	45.8 (22)	95.8 (46)	58.3 (28)
Trypanosomiasis	20.8 (10)	18.8 (9)	87.2 (41)	18.8 (9)
Pasteurellosis	18.8 (9)	39.6 (19)	87.2 (41)	14.6 (7)

TB, brucellosis, and anthrax. Only 55% of the participating veterinarians were washing their hands after contact with sick cattle. Among the veterinarians, only 50% used gloves, gowns and overalls. All the veterinary clinics that were visited for participant observations lacked water and handwashing facilities, and the laboratories boiled their equipment in hot water or a pressure cooker for disinfection. Apart from some light microscopes, the majority of the clinics lacked a functioning laboratory for disease diagnosis. Instead, animal clinics referred animal tissue samples to national laboratories for analysis if they suspected an important livestock disease of economic or public health importance.

Information sources for veterinarians in Ethiopia

The majority of veterinarians (83.3%) reported that their knowledge regarding animal diseases and treatment was a result of experience working with livestock. Additionally, this knowledge regarding animal diseases and treatment was disseminated through social networks within the veterinary community. Veterinarians also relied on farmers, and colleagues working as animal extension officers as a trusted source of information. They also reported using University training notes handouts (notes used by lecturers to train students), The Merck Veterinary Manual (MSD veterinary manuals), veterinary books, the internet (veterinary websites), standard treatment guidelines (provided by drug manufacturers), and standard veterinary guidelines/manuals as a source of information regarding emerging diseases and treatment and new developments within the wider veterinary profession.

Participant observation and informal discussion results

Participant observations and informal discussions with veterinarians in this study revealed low use of PPE, with the majority of veterinarians using only lab coats and gloves when treating livestock or doing reproductive canal examinations.

> "*There is no supply* [of] *gloves, syringes and other PPE, so this is a big challenge for us and hampers provision of a good quality animal health service* [to farmers]." Veterinarian 4, Clinic C, Oromia.

> "*As you can see in our clinic, we do not have a clinical room or space to separate risk cases. We are trying as much as possible to protect ourselves, but there is a gap* [on use of PPE]" Veterinarian 2, Clinic B, Addis Ababa.

Moreover, the clinics posed animal-to-human and animal-to-animal disease transmission risks, as sick livestock from different farms were allowed to mix at the clinics' compounds since they lacked isolation and quarantine sheds or holding areas. Additionally, animal clinics were not regularly disinfected or cleaned to reduce livestock disease transmission risks. Moreover, some clinics lacked the necessary facilities to work in or store medicine.

> "*I have been using* [disposable plastic shopping] *bags to cover my shoes when visiting farms, to avoid transmission of contagious diseases like FMD. Only a handful of farms have a foot bath with "berakina"* [disinfectant]." Veterinarian 3, Clinic C, Addis Ababa.

In all the visited clinics there were poor routines for disposal of medical waste, particularly drug vials and gloves which were often littered in the compound of the clinics. Furthermore, all the clinics lacked incinerators to dispose of infectious materials and/or animal tissues which could increase the risks of pathogen transmission within the clinics and also risk environmental contamination.

Six of the eight veterinarians engaged during the informal discussions revealed that animal health clinics often lacked drugs and that purchasing the drugs was costly, particularly for smallholder farmers in rural areas. Quality drugs were perceived as expensive and inaccessible in rural areas. The majority of veterinarians (seven out

TABLE 3 Treatments listed by the veterinarians for specific diseases, treatment duration cost mentioned by veterinarians compared to recommended management (n = 48).

Disease	Vets who said they would treat % (n)	Treatment and drugs reported by veterinarians	Treatment duration	Cost of treatment (Range, in ETB*)	Main recommendations stated by WOAH* and standard veterinary treatment guidelines of the drug administration and control authority of Ethiopia
Brucellosis	67.0 (32)	Antibiotics; Penstrip, Erythromycin, Oxytetracycline, Doxycycline, Streptomycin, Penicillin, Uterine bolus	3–7 days	300–1,500	Drug treatment: Chlortetracycline 6 to 10 mg/kg, intramuscular; other gram-negative susceptible drugs Treatment is not economical except in especially valuable animals, and even if the infection is eliminated, fertility may remain impaired Prevention: Test animals before introduction to a flock, cull infected animals, give awareness to the owner not to come into contact with foetal material and disinfect contaminated animals and surfaces
Bovine tuberculosis	63.0 (30)	Antibiotics; Tylosin, Penstrip, Isoniazid, Penicillin, Amoxicillin injection	3–7 days	200–1,500	Drug treatment: Treatment of bovine tuberculosis is not recommended because it is not economical Control and prevention: Tuberculin testing followed by segregation or culling of infected animals
Mastitis	98.0 (47)	Antibiotics, Tetracycline, Oxytetracycline, Penicillin, Tylosin, Penstrip and intramammary infusion	3–5 days	200–1,200	Clinical diagnosis by observing teat, udder and milk texture Treatment: intramammary infusion of Benzathine Cloxacillin, 500 mg for 3 days, Erythromycin 300 mg/quarter intramammary for 3–5 days Intramuscular injection of C/I, D/F, Streptomycin plus penicillin for 3–5 days
Milk fever (hypocalcaemia)	95.8 (46)	Calcium borogluconate, Calcium injection, Glucose	1–2 days	300–4,000	A typical treatment for an adult lactating dairy cow with periparturient hypocalcemia is 500 mL of 23% calcium borogluconate by slow intravenous injection. Intravenous administration is continued until the first arrhythmia is detected (a bradyarrhythmia such as a prolonged pause); the rate of intravenous administration is then slowed until a second arrhythmia is detected, at which time intravenous administration is discontinued and the remainder of the solution is placed subcutaneously over the lateral thorax
Foot and mouth disease (FMD)	75.0 (36)	Antibiotics, Penstrip, Sulphonamide, Oxytetracycline, Mild disinfectants (on wounds)	3–7 days	100–500	No specific treatment, however, supportive treatments against secondary bacterial infection are necessary Control and prophylaxis: Vaccination, test and quarantine of infected herds
Lumpy skin disease (LSD)	85.4 (41)	Antibiotics, Oxytetracycline, Penstrip	3–5 days	50–600	There is no effective treatment, but secondary bacterial infections are prevented by the administration of broad-spectrum antibiotics Prevention: Vaccination with sheep/goat poxvirus or LSD strain
Anthrax	0.0 (0)	–	–	200–2000	Drug treatment: Penicillin 22,000 IU/kg, IM, q 12 h for 2 days, then daily for 3 days or Benzathine penicillin or other repository preparations, q 48–72 h; the initial dose should be administered IV Prevention: Vaccination and animals that have died of anthrax should be burned in a closed incinerator or buried in the hole, to prevent animals not to access where animals had died. Anthrax is highly pathogenic to humans; thus, care should be taken during the handling of suspected cases
Swollen legs, abscesses and lameness	85.4 (41)	Antibiotics, Tincture of iodine, Procaine penicillin, Oxytetracycline, Penstrip, Drainage and removal of affected tissue	3–5 days	100–700	A superficial abscess may be treated by incision and drainage. Cleaning with hydrogen peroxide and iodine tincture. Isolating cattle to a housing with a smooth floor Prevention: improving the dairy house floor and applying rubber mats for the animal to lie on
Blackleg	100.0 (48)	Antibiotics, Atropine sulphate, Oxytetracycline, Penstrip, Penicillin	3–7 days	75–800	Drug treatment: Procaine penicillin G, 22,000 IU/kg, IM or SC q 24 h for 3 to 5 days or Benzathine penicillin or similar repository preparations, q 48–72 h. For S/E, C/I, D/F, D/I Prevention: Vaccination

(Continued)

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TABLE 3 (Continued)

Disease	Vets who said they would treat % (*n*)	Treatment and drugs reported by veterinarians	Treatment duration	Cost of treatment (Range, in ETB*)	Main recommendations stated by WOAH* and standard veterinary treatment guidelines of the drug administration and control authority of Ethiopia
Fasciolosis and other endoparasites	95.8 (46)	Anthelmintic drugs, Oxytetracycline, Triclabendazole, Fasionex, Penstrip, Albendazole, Bolus, Diminazine, Forsirex, Tefnocattle, Bensinedazolex	1 day and regular deworming	30–150	Treatment drugs are: Triclabendazole 9–12 mg/kg, PO stat (all stages of Fasciola). Albendazole 10 mg/kg, PO, start for mature stage Other endoparasites; anthelmintic bolus and ivermectin subcutaneous injection Control and prevention: regular seasonal deworming of animals
Trypanosomiasis	85.4 (41)	Antibiotics, Oxytetracycline, Penstrip, Topical repellent (Diminazine), Gentamycin, Diminazine aceturate (Berenil), Topical Gentamicin, Lidocaine	3–5 days	30–5,000	Drug treatment: Diminazene aceturate, Ethidium bromide and others Control: Control of tsetse flies includes frequent spraying and dipping of animals (mobile targets)., spraying insecticides on fly-breeding areas, bush clearing and other methods, insecticides-impregnated screens (fixed targets) and spray mobile target (e.g., Pour-on on cattle)
Pasteurellosis	85.4 (41)	Antibiotics, Oxytetracycline, Penstrip, Sulfadimidine, Oxytetracycline, Tylosin	3–5 days	50–2000	Drug treatment: Sulphadimidine 33%, IV, q 24 h for 3–5 days, Oxytetracycline 5–10 mg/kg IM or IV, q 12–24 h; Long-acting 20 mg/kg SC, IM or IV, q 2–4 days, -Penicillin–streptomycin 200,000 IU + 250 mg, 1 mL/25 kg Prevention: reduce animal stress and give a prophylaxis dose of Oxytetracycline long-acting 20 mg/Kg, IM

*ETB, Ethiopian birr; 1 US dollar is equivalent to 51 Ethiopian Birr (29th June 2022); *WOAH, The World Organisation for Animal Health, an intergovernmental organization coordinating, supporting, and promoting animal disease control; AI, artificial insemination.

of the eight) thought that irrational drug prescription and abuse by farmers and veterinarians were the cause of drug-resistant disease agents, and they reported that they were experiencing resistant infections which required the use of stronger antibiotics. However, despite the scarcity of drugs, the negative attitude and behaviour of farmers including imprudent use of antibiotics purchased over-the-counter drugs to treat livestock without consulting a qualified veterinarian were seen as a challenge by the veterinarians. Four of the eight veterinarians believed that over-the-counter medicines were leading to pathogen resistance and making treatment ineffective. Due to their reliance on syndromic knowledge rather than laboratory disease diagnostics, veterinarians perceived farmers as having poor skills in explaining cattle disease case history which led to insufficient information for correct disease diagnosis and treatment.

> "There is a drug supply problem and farmers complain when we cannot provide them." Veterinarian 2, Clinic B, Oromia.

Finally, three veterinarians reported that climate change was causing the emergence of new diseases and the re-emergence of endemic diseases. Cattle diseases harm livestock production and farmers' livelihoods. They also reported that seasonal feed availability and shortages were impacting livestock health and that poor nutrition meant that the cattle had low immunity to cope or fend off diseases.

Challenges faced by veterinarians in Ethiopia

The majority of the veterinarians in this survey (83.3%) reported that the lack of laboratory equipment, reagents, and material for the diagnosis of animal diseases was a major challenge that hampered their service delivery.

> "[the budget] *is below sufficient* […] *Firstly, we cannot give enough vaccines. There is a lack of enough quantity of medication here. That affects us in choosing the drug for treatment. Low availability of these medications hampers service delivery*" Veterinarian 1, clinic A, Addis Ababa.

There is a lack of accessible laboratories for disease diagnosis, particularly in government-funded clinics in Ethiopia. Veterinarians reported that their laboratory diagnosis and clinical skills were below the expected laboratory standards and norms and that there was a need for regular refresher training on disease diagnosis and treatment. Moreover, veterinarians also reported the lack of PPE which exposes them to zoonoses and other occupational risks. Finally, veterinarians cited that the lack of PPE was because of low budget allocation and a long bureaucratic procurement process.

> "*What I believe is lacking is supporting laboratory examinations to inform treatment. That is due to manpower shortage and absence of laboratory*" Veterinarian 1, clinic A, Addis Ababa.
>
> "*As you can see there is no assigned lab professional. We have a microscope and do sometimes faecal and blood samples. But it is not fully functional.*" Veterinarian 6, Clinic C, Oromia.

TABLE 4 Veterinarians' recommended management practices for the diseases.

Disease	Other recommendations given by veterinarians
Brucellosis	Vitamins, deworming, uterine bolus, giving a balanced diet, vaccinating, disinfecting the area where a cow aborts, handling aborted foetus aseptically, preventing contact with other herds, culling of affected cow, separating animals (isolation), proper disposal of the aborted foetus and the placenta, use of artificial insemination (AI)
Bovine tuberculosis	Deworming, multivitamins, giving a balanced diet, advice not to consume meat/milk, isolating the sick animal from the herd, culling the affected animal, advising to boil milk before consumption, advising on economic and public health significance, testing and culling
Mastitis	Multivitamins, improve shed cleanliness, improve milking and farm hygiene, sanitize cow udders, proper farm sanitation, disinfect the milking area, teat dipping, teat sealing, good hygienic practices, intramammary antimicrobial treatment, isolate sick cows, milk sick cows last, provide clean sleeping areas
Milk fever (hypocalcaemia)	Multivitamins, food supply with calcium content, steroids, providing the animal with well-balanced feeds, maintaining calcium in feeds, supplementing with calcium for 2–3 weeks pre-calving
Foot and mouth disease (FMD)	Multivitamins, control animal movement, limit contact with cows, annual vaccination, isolate the sick animals, proper wound management in sick animals, quarantine, washing the wound with salts, avoiding the use of community pasture, cleaning the barn regularly, and tick control
Lumpy skin disease (LSD)	Multivitamins, vaccination annually, isolation of sick cows, and good biosecurity management
Anthrax	Cull affected animals, vaccinate healthy animals, educate farmers on the handling of infected bodies, dispose of dead cows by burning, provide antibiotics early to infected cows, bury dead animals, and disinfect cattle sheds
Swollen legs, abscesses and lameness	Multivitamins, tincture of iodine, use of antibiotics, cattle vaccination, drainage and removal of affected tissue, deworming, improving cattle housing, separating/isolating and caring for sick animals, improving farm hygiene, cleaning barn regularly, keeping shed floors dry, culling chronically sick cows
Blackleg	Multivitamins, tetanus antitoxin, deworming, isolation of sick cows, increase farm biosecurity, annual vaccination, proper disposal of the carcass, preventing the animals from contact with other herds, advice on completing the dose
Fasciolosis and other endoparasites	Multivitamins, regular deworming, avoiding marshy areas for grazing, clean drinking water to be given to the animal, do not consume meat or milk from treated cows, balanced feed and nutrition
Trypanosomiasis	Multivitamins, annual vaccination, isolating sick animals, cleaning the house frequently, avoiding the use of deltamethrin, deworming, not buying an animal from trypanosomiasis affected area, monitoring drug resistance, and tick control
Pasteurellosis	Multivitamins, isolate sick animals, cull sick animals, early treatment of affected cows, have good biosecurity management, and clean and air cattle housing

Discussion

The main objective of this study was to explore veterinarians' syndromic knowledge of the common diseases they are facing, their treatment practices, the cost of treatment, their use of personal biosecurity measures, and their sources of information regarding diseases and treatment in Ethiopia. Previous studies have documented that livestock diseases, particularly cattle diseases, are a priority problem for farmers throughout Ethiopia (4, 25). Farmers have singled out poor animal health service delivery as the major constraint to improving animal health and productivity (10, 25). The findings of this study show that the majority of the veterinary practitioners had good knowledge of the most common endemic cattle diseases in Ethiopia, however, a knowledge gap was seen for cattle diseases that are not common in the highlands of Ethiopia, such as pasteurellosis and trypanosomiasis. The majority of veterinarians reported that they were likely to not use PPE when treating cattle diseases even though some of these diseases were zoonotic. The practice of treating diseased animals with antibiotics without confirmed laboratory diagnosis could lead to wrong treatments and an increased risk of circulating pathogens becoming drug-resistant. Furthermore, there were differences between the reported treatments and the standard recommended treatments by the World Organisation for Animal Health (WOAH) and the drug administration and control authority of Ethiopia guidelines.

The majority of participants in this study were male and working in government-funded animal clinics. Previous studies have reported a low number of women veterinarians in the wider East Africa, which calls for policies that can lead to retention and employment of more women in animal health services (10). Although private practices were not explicitly investigated in this study, previous studies have also reported that private veterinary practices, other than in South Africa, are very limited and under-developed, which has led to farmers' dependence on government-funded animal health services (7, 19). There is a need to increase gender diversity and the plurality of service providers and this can be achieved with the growth in veterinary medical schools in Ethiopia (5, 7, 10). Previous studies have reported that veterinary training in Africa for many years has focused on producing veterinarians to work for the state in public animal health services in the livestock sector (7). Furthermore, the human resource gap in veterinary sectors in low-income countries, particularly in sub-Saharan Africa, imposes limitations on the delivery of animal health services (38).

Veterinarians depend on their training, experience and social networks for communication regarding diseases and treatment (1, 5, 9, 10). The majority of the veterinary practitioners had good knowledge of most of the endemic cattle diseases in Ethiopia but failed to a large extent to recognise diseases such as pasteurellosis and trypanosomiasis which are not common in the highlands of Ethiopia. However, these and other diseases could in the future become more

TABLE 5 The reported personal protection equipment and infection control practices veterinarians would use in disease scenarios (n = 48).

	None	Hand wash after contact	Gloves only	Gown/ overalls only	Gloves & gown/ overalls	Gloves, gown/overalls & face protection (respiratory mask and goggles)	Gloves, overalls with head protection, P2 respiratory mask and goggles	Not sure
Brucellosis	0.0 (0)	54.2 (26)	10.4 (5)	16.7 (8)	29.2 (14)	37.5 (18)	10.4 (5)	2.1 (1)
Bovine tuberculosis	0.0 (0)	50.0 (24)	4.2 (2)	6.3 (3)	31.3 (15)	39.6 (19)	8.3 (4)	14.6 (7)
Mastitis	4.2 (2)	50.0 (24)	8.3 (4)	8.3 (4)	41.7 (20)	14.6 (7)	2.1 (1)	18.8 (9)
Milk fever (calcium deficiency)	8.3 (4)	41.7 (20)	6.3 (3)	8.3 (4)	41.7 (20)	18.8 (9)	0.0 (0)	2.1 (1)
Foot and mouth disease (FMD)	10.4 (5)	56.3 (27)	6.3 (3)	8.3 (4)	35.4 (17)	29.2 (14)	8.3 (4)	6.3 (3)
Lumpy skin disease (LSD)	2.1 (1)	43.8 (21)	10.4 (5)	6.3 (3)	50.0 (24)	22.9 (11)	6.3 (3)	14.6 (7)
Anthrax	18.8 (9)	43.8 (21)	2.1 (1)	4.2 (2)	27.1 (13)	27.1 (13)	25 (12)	6.3 (3)
Swollen legs, abscesses and lameness	18.8 (9)	41.7 (20)	8.3 (4)	10.4 (5)	41.7 (20)	16.7 (8)	2.1 (1)	4.2 (2)
Blackleg	16.7 (8)	43.8 (21)	4.2 (2)	14.6 (7)	58.3 (28)	6.3 (3)	4.2 (2)	0.0 (0)
Fasciolosis and other endoparasites	14.6 (7)	52.1 (25)	6.3 (3)	8.3 (4)	43.8 (21)	8.3 (4)	0.0 (0)	0.0 (0)
Trypanosomiasis	14.6 (7)	50.0 (24)	8.3 (4)	4.2 (2)	37.5 (18)	27.1 (13)	0.0 (0)	0.0 (0)
Pasteurellosis	18.8 (9)	37.5 (18)	2.1 (1)	6.3 (3)	41.7 (20)	14.6 (7)	8.3 (4)	4.2 (2)

Results in % (n).

prevalent in the highlands due to climate change, globalisation, and the introduction of new cattle breeds susceptible to endemic zoonoses (4). The case descriptions were only of a selected number of diseases, using typical pathognomonic symptoms, and the study did not evaluate how vaguer symptoms would have been diagnosed, such as a case of only abortions, which could be due not only to brucella but also to some other diseases, including those with bacterial and viral origin (39).

The results reveal low disease reporting and notification although it is a mandatory requirement to file weekly reports on cases attended at the animal clinic. Low notification of diseases hampers disease surveillance which could be detrimental to animal health management (4, 22, 39). Previous studies have reported the underfunding of veterinary services in sub-Saharan Africa that hampers animal health service delivery (4, 19). There is a need for animal health services investments as envisioned in the "One-health approach" given the numerous endemic livestock diseases and zoonoses in sub-Saharan Africa (4).

The results of this study show that the recommended treatment suggested to farmers occasionally was not in line with the recommendations of the WOAH and the guidelines from the drug administration and control authority of Ethiopia (Tables 3, 4). For the majority of diseases, the surveyed veterinarians could propose treatment methods which they reported were based on their experience and information from their social networks. The choice of antibiotics used by veterinarians in this study is similar to what has been reported in previous studies in sub-Saharan Africa (40) and also in India (41). Moreover, there is a need to ensure that farmers have access to qualified veterinarians to get information and advice on the prudent use of antibiotics particularly concerning the use of over-the-counter drugs to treat livestock which creates the risk for AMR (22, 42, 43). Moreover, the practice of using antibiotics for prophylaxis contravenes antimicrobial stewardship and could exacerbate the challenges posed by the development of AMR pathogens (10, 22, 41). Previous studies have shown that the indiscriminate use or misuse of antibiotics by veterinarians and farmers for animal treatment contributes to AMR problems (10, 22). It is thus imperative for training and awareness creation on the risk of AMR and the need for antibiotic stewardship (40, 41).

The extra services and advice recommended by veterinarians to farmers in this study (Table 4), such as improvement in animal feeding, vaccination, use of AI and adoption of farm biosecurity measures, can reduce disease prevalence, and improve food safety, animal health and welfare (7, 12). Veterinarians are professionals in close contact with farmers and thus are trusted sources of information (44, 45). Adoption of farm biosecurity measures and improved farm hygiene practices as recommended in the findings of this study has the potential to reduce livestock disease prevalence at the farm and lead to improved food safety for consumers (8, 12).

Veterinarians working in government-funded animal clinics faced challenges such as lack of PPE, underfunding of the animal health services budget and low supply of essential medicines and pieces of equipment. There was a low reported use of PPE, a behaviour that exposes veterinarians to occupational risks including exposure to deadly zoonoses such as anthrax, bovine TB, and brucellosis. There is a need to increase the use of PPE to reduce the risk of zoonotic diseases in their day-to-day occupational activities (11). Moreover, the poor disposal of medical and animal tissues at animal clinics could contaminate the environment and lead to the transmission of livestock diseases, particularly those that can persist in the soil and groundwater, such as anthrax and Q-fever (7, 46).

The majority of veterinarians obtained information on animal diseases and drugs from their social networks, training manuals and their lived experience. Previous studies have reported the importance of experience and syndromic knowledge for disease diagnosis and treatment (7, 47). There is a lack of a centralised

information system in the Ethiopian veterinary sector which constrains the quality of animal health services (7). Similar to the findings of this study, Gizaw et al. (25) recommended the establishment of an integrated animal health information system to improve veterinary service delivery in Ethiopia. The use of new media technologies can help bridge the information gap while at the same time providing new avenues to learn new skills and technologies (48, 49).

The adoption of new and emerging technologies can provide cheap and innovative solutions that can address the lack of diagnostic facilities (49, 50). The lack of laboratory facilities as evidenced in this study can be addressed through new emerging technologies such as mobile diagnostic units, digital technologies, rapid test kits and telemedicine which can improve disease surveillance and diagnosis capabilities in remote and resource-poor settings (50, 51). However, to leverage these new emerging technologies, there is a need for private and public sector investments in procuring rapid test kits, training on how to use the new technologies, and expanding access to the internet (49, 50). Increasing access to animal health information such as animal disease outbreaks is crucial to safeguarding animal, human and environmental health and livelihoods (7, 10). Although beyond the scope of this study, there are opportunities to leverage community animal health workers and extension workers to advise farmers and provide routine services to livestock farmers which can improve access to animal health services (52, 53). Moreover, adopting new and innovative technologies can contribute to the retention of women veterinarians in the workforce in emerging economies such as Ethiopia by removing barriers that make women leave veterinary occupation such as salary, work-family balance, working hours, and workload (54, 55). Expanding women and youth participation in animal health services can create more resilient and responsive veterinary health services that reflect local needs and contextual realities (55–57).

The findings of this study show that veterinarians rely on experience and syndromic knowledge to provide animal health services due to a lack of diagnostic facilities. There is therefore a need for regular training to ensure that veterinarians are aware of new emerging zoonoses and re-emerging zoonoses (7, 10). Training veterinarians on interdisciplinary thinking and collaborative working such as the implementation of One Health-focused training can harness existing knowledge and resources to improve health human, animal and environmental health (29). Global and regional initiatives such as Africa One Health University Network (AFROHUN), the International Livestock Research Institute (ILRI), the Food and Agriculture Organisation of the United Nations (FAO), and the One Health Research, Education and Outreach Centre in Africa (OHRECA) project are working to transform the training and capacity building in Africa which could benefit veterinarians working in resource-poor setting (58, 59).

Limitations

This study looked to explore how livestock treatment occurs in a real-world environment in Ethiopia and how veterinarians diagnose and treat cattle diseases. In this study, we did not have the exact number of practising veterinarians in the areas we were undertaking research and as such we relied on convenience and purpose sampling to reach as many respondents as possible. Moreover, due to COVID-19 and the civil war in Ethiopia, the lead researcher's travel plans were restricted to the relatively safe areas permitted by the Ethiopian government which made it impossible to reach as many veterinarians as we could have wanted which could have created a selection bias towards veterinarians who were easily accessible under the prevailing circumstances at the time.

Although this study provides insight into animal health services in Ethiopia, the sample size was too small to generalise regarding trends across the country. We believe our choice of mixed method approach involving qualitative and quantitative data provides an insight into the general trends across the country. Future studies should therefore aim for bigger sample sizes, and reach a diverse set of animal health practitioners (e.g., veterinarians, paravets, community animal health workers). Moreover, experiments and longitudinal research approaches could also explore the causality between the quality of animal health services and animal health outcomes. Future studies should also explore how new modern technologies such as digital technologies and rapid test kits can improve animal health services and also improve animal disease monitoring and surveillance.

Finally, due to budget limitations, this observational study was not set to compare syndromic knowledge and clinical diagnosis of disease through laboratory analysis. Future studies should compare the accuracy of syndromic knowledge to laboratory analyses to explore ways to help veterinarians in their disease assessments given that most livestock treatment still depends on experience and syndromic knowledge. There is a need to ensure that correct disease diagnoses are made before administration of treatment to mitigate and avoid AMR.

Conclusions and policy implications

Poor quality of animal health services has been documented in Ethiopia. There is an urgency to improve the coverage and quality of veterinary services across Ethiopia to improve productivity, animal welfare and public health. Veterinarians play an important role in preventing and treating livestock diseases and also safeguarding human health. However, their capacity to offer quality services is constrained by underfunding and the absence of infrastructure such as the lack of laboratories, PPE, understaffing and underfunding of animal health services constrain livestock production. Policymakers should prioritise the establishment of a national veterinary health information system for animal disease monitoring and surveillance. Moreover, there is a need for policies that provide incentives for private sector involvement in veterinary services to bridge the animal health services coverage gap and particularly serve farmers who are willing to pay for animal health services.

There is a need for a concerted multi-sectoral approach to improve veterinary service delivery through improved veterinary infrastructure and public-private partnerships. The absence of diagnostic facilities and susceptibility tests hinders the prescriptions of the right antimicrobial drugs, which could subsequently lead to increased AMR. Increased funding, continuous training, improved access to information and investment infrastructure such as laboratories would enable veterinarians to deliver quality animal health services to farmers. Additionally, there is a need to encourage veterinarians to adopt

and use protective biosecurity measures to reduce their exposure to zoonoses.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

NN: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. JW: Funding acquisition, Methodology, Resources, Supervision, Writing – review & editing. GG: Data curation, Project administration, Writing – review & editing. SB: Methodology, Project administration, Supervision, Writing – review & editing. AM: Project administration, Supervision, Writing – review & editing. JL: Methodology, Supervision, Writing – review & editing. HM: Funding acquisition, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Culture of care: the question of animal agency in laboratory animal science

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Background: A majority of the current debates in experimental animal science research focus to a large extent on the significance and implementation of the 3Rs principle according to Russell and Burch. In this context, not least due to the EU Directive 2010/63/EU, the concept of a culture of care has become more prevalent. Although animals are essential actors in the field of laboratory science, the discussion around animal agency, as well as the resulting consequences for laboratory animal science, is currently unconsidered.

Methods: The purpose of this qualitative survey was to identify the perception and understanding of professional workers in laboratory animal science regarding the culture of care in general and aspects of animal agency in particular. Using a non-standardized qualitative survey method (topic-oriented, guideline-based expert interviews), persons involved in animal experimentation in different groups (management, science, regulation, and care) were interviewed.

Results: Overall, the results of the qualitative survey showed that animal agency plays a subordinate role in the question of a culture of care in animal research. Although not all groups explicitly applied the construct of animal agency or comparable terminology for this, there were links to the theoretical construct. Overall, the interviews showed a recognized network between humans and animals and that animals can interact dialogically in research. This is justified, for example, by the transfer of emotions from carers or scientists to animals. Nevertheless, a differentiated reflection of an animal's agency remains disregarded.

Conclusion: The present qualitative survey approached the understanding of a culture of care among experts in the field of animal research. Animal agency does occur in the theoretical reception of the culture of care model. However, it is not conclusively established in everyday practice. Rather, the results lead to the assumption that strategies are being implemented to largely fade out animal agency.

KEYWORDS

human–animal studies, qualitative research, expert interviews, multispecies ethnography, animal ethics

1 Introduction

In 2010, the European Union adopted Directive 2010/63/EU, thereby creating an instrument for European member states to implement effective measures to regulate animal experimentation by law. The implementation of the 3Rs concept by establishing a culture of care in the sense of a "Climate of Care" is explicitly mentioned in Recital 31 of the EU directive but has not yet been conclusively established.

A majority of the current debates in animal sciences focus on the importance and implementation of Russell and Burch's 3Rs principles. The most cited content in the authors' study relates to the description of the tools for implementing "humanity," through the 3Rs, which are replace, reduce, and refine. Replace describes a replacement of animal experimentation with an alternative procedure. If this is not possible, the smallest necessity of animals should be used, in the sense of reduce. If experiments must integrate animals, an effort should be made to refine the studies so that the laboratory animals used endure the least possible amount of pain, suffering, or harm. This is in addition to the reduction in stress and the best possible preservation of the wellbeing and welfare of laboratory animals (1).

Welfare "has been used in the animal research literature to mean simply the absence of distress, but it also can be and has been used to refer to a number of different positive mental states-ranging from very mild and brief feelings of comfort; to feelings of great comfort; to satisfaction resulting from eating, drinking, and the fulfillment of certain basic physiologic needs; and to mild pleasures, intense pleasures, feelings of happiness, and happy lives" (2). The attribution of feelings, happiness, and the parameters of wellbeing in laboratory animals is closely linked to the conclusion that "laboratory animals respond to many, if not all, of the activities occurring around them both behaviorally and physiologically" (3).

The importance of human–animal relationships has been shown to have an impact on animal stressors (4, 5). Positive interactions with caregivers reduce abnormal behavior, increase species-specific behavior, and promote coping skills that help attenuate stress reactivity to novel objects or situations (6). Positively oriented interactions with animals also lead to increased morale and job satisfaction among caregivers, resulting in better care and improved animal welfare (7–9). This is linked to current debates on the One Health (10) and One Welfare approach (11).

Russell and Burch's statements allow for initial conclusions about the complexity of the principles. This implicitly illustrates a necessity for reflection on procedures in organizations and attitudes toward animals and links this to the concept of a culture of care (12).

Culture of care finds its roots in the area of nursing and health promotion with a foundation in communication (13). However, a differentiated view shows more parallels to culturally sensitive nursing. The term is used when people with different cultural contexts interact to build a high-quality relationship in care (14). At its core, it is characterized by trust-building words, gestures, moments, and touches and is linked to an inner attitude. This includes that people, regardless of their worldview, origin, or social position, are valued and that they are treated with empathy and compassion (15). In comparison, the term culture of care is generally used in the laboratory animal community to indicate a commitment to improving animal welfare, scientific quality, care of the staff, and transparency for the stakeholders (Norecopa). The concept describes a transformation of existing routines and procedures toward dialogical processes of negotiation and reconceptualization of all groups involved. All groups involved (management, science, regulation, and care) are understood as multipliers in the 3R implementation and the implementation of a culture of care in the sense of appreciation, care, and the wellbeing of all actors (16). A multiplier is a person or institution through which knowledge and information pass through its dissemination and reproduction to other people and organizations.

In summary, the concept of a culture of care describes (17–19):

- Commitment to the implementation of the 3Rs;
- Creating an appreciative working atmosphere;
- Institutional engagement on behalf of animals (leadership has a key role);
- Motivation building and promotion of creativity of all employees;
- Barrier-free communication within and between all groups of an organization;
- Remodulation of values, beliefs, and attitudes;
- Professional and interactional promotion of all actors;
- Strengthening the self-organization of each individual;
- Lifelong learning in the sense of ongoing training programs for all groups;
- Appreciation of humans and animals.

Russell and Burch's study contains relevant links to the culture of care, even if it is not explicitly named as such. They aim for the existence of a friendly and constructive attitude toward the animals used, which serves as a means for the (further) development of experimental techniques. This includes the inclusion of philosophies that prohibit attributing consciousness to animals (12). One approach to countering this is Singer's animal ethics, which fundamentally assumes that the sentience of animals is linked to consciousness (20). When applied to research with animals, this means—despite the difficulty of objectification—that a debate on the question of animal consciousness and its implications for scientific research is necessary to think about the inclusion of this aspect within experimentation.

The 3Rs are used all over the world, although it must be emphasized that considering the 3Rs alone can lead to a rationalization of the concept without embedding it in its original context. The quotations usually refer to Refinement, Reduction, and Replacement. However, Russell and Burch's ideas on humanity and inhumanity with reference to subjectively perceived but ignored parameters remain unknown. Consequently, the different reception of the authors can lead to the fact that the highest goal of Russell and Burch, namely the complete renunciation of sentient beings, cannot be achieved (12). With reference to this, Russell and Burch also refer to a fundamental objective of their work as being "to create a new discipline of applied science." The aim of the authors is to counter direct contingent cruelty (inhumanity) toward animals in biomedical research by integrating reflection processes from an animal's perspective (21). These can be understood as relevant characteristics of a future culture of care. In conclusion, it is therefore logical that the perception of these research findings has criticized problematic situations due to the treatment of laboratory animals (22, 23). These have contributed to further reflection on established (social) organizational culture(s) of animal research and a discussion and (self-) reflection about the culture in animal research (17).There have been an increasing number of conferences and workshops about the culture of care. Nevertheless, the current debates linked to the 3Rs and culture of care exclude an essential part, namely, the deeper and differentiated analysis of animal agency (16).

This exclusion reveals a major shortcoming of the conceptualization. The microperspective view of animals does not

go beyond a mere discussion of the broad term "well-being" or the rationalized aspects of the 3R principles. The idea of animal agency in animal sciences is the ability to make decisions based on the animals' interests and respect animal rights (24, 25). Legal animal rights linked to animal agencies ensure that the interests and personalities of animals matter and that this is qualitatively balanced and discovered in research. Moral status can therefore be equated with the moral consideration of interests (25). Although Russell and Burch and the concept of culture of care do not explicitly name the construct of animal agency, their explanations do already show links to its concept. For example, Russell and Burch explicitly address the network of effects and interactions that arise between humans and laboratory animals (1). Their first thoughts can be linked to current debates about animal agency within the field of human-animal studies, e.g., the social sciences, humanities, or interdisciplinary human–animal studies. Russell and Burch recommend an integration of the ambivalence between humanity and inhumanity within research. The characteristics of a culture of care address an appreciation of animals, an engagement with them, and a remodulation of beliefs, values, and attitudes.

Animal agency as a theory is described as a construct that integrates free will, ability, rationality, mind, morality, and subjectivity for animals (26). The first debates focused on agency were human-centered and were oriented toward anthropological approaches and questions about social and political organization. The agency is species-bound and contextualized through dichotomies, power relations, and moral concepts at the interface of the human–animal bond (26–28). Following on from philosophical and sociological approaches, animal agency can be defined as acting, action, and influence with the inclusion of animal morality (26, 29–32). It integrates an acceptance of sense and intuition and the various emotions and faculties, such as love, memory, attention, curiosity, imitation, and reason (29).

Russell and Burch also address the consideration of animals' emotions as an integral part of animal research. Animals show physical and psychological species-specific and individual behavior and expression, which is linked to ethical behavior. McFarland and Hediger describe the gorilla Binti as an example of this. Binti took a boy who had fallen into her enclosure in her arms until the animal keepers took the child. Binti acted like a moral being, which allowed the authors to see evidence of the presence of animal agency (26, 33–35).

Linguistic research shows that animals participate in communicative and symbolically based worlds in various and very fundamental ways (36). Ethological studies confirm the species-specific and individual behavioral and expressive patterns of animals (27).

Animal agency is formed within social interactions, in which animals can act socially and enter into relationships. Interrelated behavior is linked to the existence of a social relationship and social action through feelings, moods, body positions, body language, and facial expressions (37–40). Animal agency becomes apparent through four elements: agency through time and space, practice and routine, agency in the social environment, and agency through social norms. Recognition of this is linked to empathy for different species (41). This allows for a discussion on what it is like to be (like) the other. However, it does not answer the question of "what it is to be 'with' the other" (42). Multispecies ethnography is also linked to this approach, which is a research method that seeks to combine animal perspectives with interdisciplinary-oriented research approaches by integrating (auto-)ethnographic analyses of human and laboratory animal interaction(s) (43).

In relation to the theoretical reception of animal agency in the literature, it can be characterized and summarized as the capacity of animals to make decisions, determine and take action, and organize themselves individually and as groups. It includes the recognition of animals' voices (44) and their capacity to act intelligently, rationally, and intentionally (45).

In this context, the analysis of stress and behavioral aspects such as fear or other mental states of animals has not been sufficiently revealed in animal research (2). Nevertheless, it is therefore very impressive that animal perception and personality are named and linked to philosophies that attribute consciousness to animals. Consciousness means that the interests of all sentient beings are morally significant. Sentience describes the ability to have positive (pleasant and attractive) and/or negative (unpleasant and aversive) experiences, both physical and emotional. They arise in interactions and through reactions with the environment. Indicators could be signs of rejection by withdrawing, refusing, or screaming, which shows an unwilling participation (46). Therefore, a deeper analysis and understanding of what that means are missing. Researchers should look "for what is being unconsciously ignored" (1). With reference to the theoretical concepts of animal agency and the 3R concept, an animal's perspective is not given sufficient consideration. Attempts are indeed being made to strengthen animal welfare and well-being through, for example, ethical application formats and the assessment of stress. However, a critical view of this addresses an ignorance of parameters that go beyond animal welfare parameters (47). These include, for example, perceived personality traits of animals or exhibited behaviors that are not relevant to the planned research project. As a consequence, animals in the animal sciences are not conclusively understood as physical-spiritual entities that can act meaningfully and exert a reflexive and active influence on their environment through individual self-determination (44, 45).

Although Russell and Burch's study and the concept of culture of care can be linked to the ideas of animal agency, the interdependence has not been analyzed, nor has the EU directive or the concept of a culture of care integrated animal agency sufficiently.

At present, there are no empirical data about animal agency in the context of a culture of care in Germany. This means that we currently do not know what animal agency means for people or how or whether animal agency is taken into account in practice.

With the help of explorative qualitative research (expert interviews in various groups: management, scientific, regulation, and care), an animal agency within the concept of culture of care was examined (19). This article examines the specific research question of animal agency from the perspective of employees at different levels at institutions involved in animal research and offers the first hypothesis about the implementation of this theoretical approach in practice.

This article addresses this research gap at the interface of the 3Rs, culture of care, and animal agency.

2 Materials and methods

2.1 Objective

Data collected are based on a qualitative approach with non-standardized, topic-oriented, guided expert interviews. The

interviews were conducted with people associated with animal experiments at various levels (management level, scientific level, supervisory level, and care level). This qualitative approach allows for theoretical, methodological, and methodical approaches to social reality (48, 49) by analyzing the perception and understanding of culture of care in general with regard to animal agency in particular.

The research questions are intended to highlight the characteristics of a culture of care from a personal and institutional perspective. Sub-questions differentiate the research and offer insights into thoughts and beliefs about animal agency.

The studies involving human participants were approved by the Justus Liebig University Giessen. The study involving human participants was conducted in accordance with the European General Data Protection Regulations and with the Code of Ethics of the German Sociological Association.

2.2 Methods

Since the field of research on animal agency is currently very lacking in Germany, an explorative approach was chosen. Explorative expert interviews are particularly suitable when there are few or no examples of theoretical or empirical data available. All actors involved offered multi-layered insights and perspectives that included knowledge, action, and their social meaning (48).

The qualitative approach with small cases does not aim to generate countable or measurable results. Rather, individual expert perspectives and experiences are considered within the contexts, conditions, strategies, and consequences. These offer insights into a perception of animal agency in animal sciences (50). The sample is based on theoretical sampling. Participants were selected based on their potential for developing and refining theoretical concepts. Experts with a perception of the theoretical framework were chosen, as well as experts with no perception. This assumes that the sample size was achieved because additional data will not produce any relevant new findings (51).

2.3 Field excess

All participants were unknown to the interviewer. The participants were recruited via stakeholders and distributors and could decide whether they wanted to participate or not. All participants received written information about the procedure and signed a consent form regarding their participation.

Field access was very challenging, especially for the group of scientists as well as the management group. More people had to be approached, as there was less willingness to participate. In some cases, scientists were instructed by their managers not to discuss any information about individual research projects. The regulatory group and the care group showed great openness and commitment to participation.

2.4 Sampling

Between October 2020 and January 2021, a total of 14 experts in animal-based research were interviewed. They came from multiple labs and institutions throughout Germany. Experts worked with laboratory animals and were employees at institutions that are actively involved in animal research. These were assigned to four organizational groups: management, science, regulatory, and care. The management group included all experts in a management function, such as a working group leader, veterinary manager, or head of an animal facility. The science group included all experts with a scientific focus, such as postdocs and doctoral students or technicians. The regulatory group included all experts who carry out supervisory activities in the context of animal research, such as animal welfare officers or authority representatives. The care group included all experts who are responsible for the care of the animals, such as animal caretakers. It should be noted that the roles of experts may overlap between the groups.

Methodologically, the sample was chosen in such a way that "every reality of the phenomenon under investigation" was present (52). Three people each were interviewed for the management and scientific groups, and four people each were interviewed for the care and regulatory groups.

In summary, the interviews addressed the individual process of working with laboratory animals over time, the definition of culture of care, and links to animal agencies.

All interviews conducted were transcribed and provided with field notes and memos. Care was taken to consistently anonymize all participants. The participants needed to suffer no disadvantages from participating in the research, which is why protection was assured in writing. All interviews were productive and based on trust (53).

2.5 Evaluation

The analysis of the culture of care required a complex consideration of all groups. The basis of the analysis was the assumption of a relationship between humans and animals (54).

Analysis with grounded theory using MAXQDA, a qualitative data analysis software, allowed for data collection with expert interviews and by theoretical sampling—simultaneously coded and analyzed. This process was guided by theory and allowed for the integration of animal agency from the experts' perspective (55). All codes were generated when aspects of animal agency were addressed within the interviews. The interview passages of the participants within the text were translated from German to English.

3 Results

This section is divided into different groups. It provides a concise and precise description of the results and their interpretation, as well as the conclusions. The results of the qualitative interviews show a differentiated representation of animal agency about a culture of care. For a better understanding of the data, the presentation of the results was first divided into individual groups. This was followed by an overarching conclusion for all groups to classify the significance of agency from a meta-perspective.

3.1 Management group

The management group emphasized less implementation of the concept of culture of care. Two managers were barely aware of the

concept before the interview. One manager emphasized that the culture of care is already being integrated into his understanding and everyday work. Communication plays a key role in the care of the animals, as well as the legal framework and financial planning of the activities within the organization. In the argumentation for implementing a culture of care, systemic parameters were highlighted as barriers, for example, the pressure to publish or inconsistent jobs. Job practice in the German science system causes negative effects on humans and animals, as the following quote illustrates:

> "The most glaring effect is that research results are generated and animals are used for them that actually have no value because they are based on a false premise. Then the animals are virtually useless, in the best case they have died, in the worst case they have been subjected to some painful or stressful procedure. Something did come out of it – in the sense that something was published in the end – but it did not actually contribute anything to the actual gain in knowledge." (Animal House Direction).

The management group also highlighted the necessity of education to implement the 3Rs and a culture of care. It is fundamental for animal welfare and stimulation of internal reflection and individual roles. These also refer to a fundamental questioning of one's activities. In this context, the question of the animal as a product was also raised in the sense that animals can be used strategically and be scientifically useful for scientific output.

A quote from one manager illustrates this:

> "I think everyone who does animal experiments sooner or later comes into a crisis. I have experienced these crises several times in my life and actually not a month goes by where I do not ask myself: Is this actually justifiable?" (Professor).

In this context, the person points out that this reflection includes the fact that the individuality of the animals exists:

> "The individuality of the laboratory animals, which we have tried to eliminate for decades, is still there." (Professor).

Although shades of animal agency became visible, the term itself was not mentioned. Therefore, animal perspectives were not given deeper consideration.

3.2 Regulatory group

The regulatory group emphasized the importance of close contact with other organizational groups involved, especially with other regulatory actors, scientists, and management. The differentiated analysis indicated self-discipline and the ability to reflect as markers for a culture of care, as well as respect for animals and communication between all groups.

An animal welfare officer stated the following in connection to animal agencies:

> "An essential aspect of implementing a Culture of Care is a change of perspective. I believe that in order to really process things." (Animal Welfare Officer).

Giving animals a higher status and reflecting their perspective within experimental procedures helps to improve methods. Furthermore, a reflection on subjectivity within research gives new insights into interpretations from a human-centered perspective.

One expert of the regulatory group emphasized the fundamental question of indispensability and the ethical question of the "self-evident" use of animals (agency representatives). Shades of the animal agency were recognizable. However, animal agency in a deeper sense was seen critically by an authority representative:

> "But to what extent animals are able to influence something like that, I do not know, so with rats, rats are intelligent anyway, I do not know if rats are willing to influence anything. Monkeys maybe." (Authority Representative).

3.3 Science group

Culture of care was largely associated in the science group with providing animal welfare. In this context, communication between all groups was described as relevant to implementing animal welfare. Animal caretakers were named as mainly being responsible for ensuring animal welfare. References to animal agencies were not directly made. However, the effects of interactions between humans and animals were emphasized and reflected upon.

> "When I deal with the animal in a calm and balanced way, radiating a certain aura. Then the laboratory animal will also respond to that. But if I'm totally stressed because I want to be ready quickly, because I have to go to the lab somehow after the animal house, then that also has a very strong effect. That's why the most important thing is to always remember that you are really working with living beings and that you should take your time and rest for it. Even if that is sometimes difficult in a workday." (PhD Student).

Reflection on working with animals played an important role in the science group. Emotions of humans and animals were named as being interwoven. This emotional bond becomes more relevant when animals are killed.

> "I've also had everyone tell me that there is actually no one who is completely unaffected. You just learn to deal with it, to put it that way." (PhD Student).

Both quotations give insights into the emotions of workers and their connection to animals. By addressing this, an inner conflict can be seen. Nevertheless, the quotes spoke to a strategy to deal with these emotions: focusing on objective parameters within research and accepting the facts.

Any subjective parameters that may arise were not considered. It is therefore not surprising that animal agency is seen as a form of influence but would not actively take place:

> "I do believe that animals can actually influence a great deal, but of course they do not actively do so." (PhD Student).

The science group showed shades of recognition of animal agency but pushed aside individual needs and emotions, which reflected on the animals' needs, emotions, or personalities.

3.4 Care group

The care group showed a differentiated view and mostly supported the implementation of the 3Rs. The majority of the participants did not know the concept of the culture of care. Furthermore, the construct of agency was not explicitly mentioned. Nevertheless, the care group saw themselves as having a high level of responsibility for the animals:

> "We have a certain responsibility as animal keepers and above all we really provide some protection for the animal during our work, educate ourselves to then be able to handle the animal better." (Animal Keeper).

This also revealed an inner conflict in the form of an ambivalence dilemma, which was also named earlier in the science group. The strategy for dealing with the activity and the killing of the animals places higher stress on the care group. This requires finding strategies to deal with this:

> "When I really get out of my area, I can switch it off and then I do not think about the part I did there at work. […] It developed relatively early in the training that you have to realize that. I have a different opinion in my head about the subject than how I actually work. That developed relatively early in my life: This is work and this is private life." (Animal Keeper).

As was already mentioned in the science group, the ambivalence dilemma was overlooked or even ignored. The attributions and social constructions of the participants to the animals showed links to the construct of animal agency, always in connection with interactions:

> "Mice also show sympathy. If someone is hectic, the mice are hectic and you notice it when an animal keeper changes. If one animal keeper is on holiday and someone else takes his place, the mice are also a bit more hectic when they are first moved." (Animal Keeper).

It can be concluded that animal agency is linked to complex emotional conflicts, which are also described in the scientific community as compassion fatigue syndrome (47, 56). The distance or absence of emotions is described as an element in being able to perform certain activities, such as euthanizing animals. The exclusion of individual emotions logically prevents the ability to empathize with other beings. It is therefore not surprising that animal agency has not been noted more deeply, as the following quote states:

> "I have to be honest and say that I have not yet noticed this in mice." (Animal Keeper).

4 Discussion

Overall, the results of the qualitative research showed that animal agency plays a subordinate role in the question of a culture of care in animal sciences. The lack of consideration of animal agency is consistent with the literature in animal sciences and highlights a blind spot in the current debates about culture of care within the scientific community of animal research.

Although no interviewed groups explicitly applied a recognition of animal agency in everyday practice, relevant links to its theoretical construct can be made.

Overall, the results showed a general recognition of the networks between humans and animals and that animals are attributed to an agency in which they interact dialogically. This is justified, for example, by the transfer of emotions between care workers, scientists, and animals.

Named external and internal conflicts regarding the activity and killing of animals allow for further conclusions about the concept of animal agency in animal sciences. The participants explicitly mentioned strategies of demarcation to counter discrepancies with their own values. It can be assumed that this is one reason why the agency occupies less space within the concept of culture of care.

The results reveal a major issue regarding values and beliefs in connection with professional identity (47).

However, objectified research is emphasized as an essential quality criterion and strategy, so that essential aspects, such as emotions or individual values, are automatically excluded—as Russell and Burch already noted. In recent debates, scholars have pointed out potentially subjective and ignored parameters (25). For example, Helena Pedersen named the fragility of objectivity in an exemplary research study with chickens. Although the chickens involved behaved in an experimental situation, they were able to influence the experiment through their agency. The researcher's subjective assessments became visible in her reflection but were not made available to the scientific community (57). Another example is that the gender of workers had an influence on the behavioral parameters of tested animals (58).

Although aspects of the animal agency have already been discussed, no research about the animal agency or subjective parameters in animal sciences has been adequately linked beyond usual standards.

Thus, if we assume that consideration of animal agency is practiced on an individual basis, this aspect is supported by our research.

5 Conclusion

Overall, both the theoretical reception of animal agency and the results of the qualitative data offer insights about a missing perception of animal agency in debates around the culture of care. As a result, culture of care could, in its current form, result in the establishment of procedural rules through the use of animals in animal research.

However, a deeper and more reflective approach offers animal agency as one core element of a culture of care. Even though it is not referred to as an animal agency within the concept, animals and their appreciation are included. The animal agency goes beyond the legal regulations of institutions, general acceptance of the 3Rs, and ensuring animal welfare. It means that a transformative attitude on the part of individuals and institutions is necessary if animal agency is to be taken into account.

However, the study aimed for an understanding of the characteristics of a culture of care among professionals. Nevertheless, an underrepresentation of animal agencies in animal research was noted, and a consensus about the absence of a deeper influence on animals was highlighted.

With reference to the theoretical reception of Russell and Burch and the concept of culture of care, an increasing lack of consideration of animal agency remains, which leads to a blind spot in attitudes toward animals. For animals, this means that their character, ability to interact, individuality, needs, and voice are not sufficiently holistically heard within animal research. To address this gap, a transformation and cross-disciplinary work may be beneficial. Using multispecies ethnography allows for a new possibility of approaching animals. Multispecies ethnography describes an ethnographic method that observes and reflects human–animal bonds. By conceptualizing animals as social actors with agency, this helps question established routines and methods. It is generally recruited for research that acknowledges the interconnectedness and inseparability of humans and other life forms of the more-than-human world, such as animals (59). Multispecies ethnography offers to reconstruct interactions and social relationships between humans and animals in the animal sciences. (60)

In the first step, the methodology allows for a shift by including people writing about people and animals. This requires that common and established rules are broken and previous knowledge is questioned to make it useful for analyses of animal agency. The heuristic tool offers seeing everything through the eyes of an animal. It combines sensorial, visual, and video-based research methods with an ethnographic focus and consideration of different species. Animals are perceived as living beings with their own experiences, sensations, perspectives, and interests (61, 62). Consequently, the subjectively perceived parameters of researchers are highlighted by integrating the emotions, feelings, and perceptions of people working with animals in the animal sciences (56). Regarding and respecting animal agency in labs will allow animal sciences to re-think and reflect upon organizational structures and open their expertise to animals' perspectives. Integrating this allows for a transformation in organizational development for humans and animals. It is, therefore, necessary for further research projects to address concrete markers of how a consideration of animal agency can be integrated within laboratory animal research.

To address this gap, reflection questions are required to implement a critical and reflective perspective on the animal agency.

1 What is the use of animals helpful for?
2 How are interactions between humans and animals in laboratory animal research organized?
   a What is the value of observing animal interactions, and how are they categorized?
   b What interactions do animals show with humans, and how are these interpreted by the caregivers, always in reference to their values, emotions, and beliefs?
3 What emotions do interactions with animals release in the caregivers?
   a Which emotions are recognized in the perceived behavior of joy in animals?
   b Which emotions are recognized by the perceived behavior of fear or stress in animals?
   c Which emotions are recognized when animals are killed (after they have been cared for)?
4. Which forms of consideration of the interest and personality of animals are considered in everyday practice?
   a What consequences does this consideration have for the regular procedure?
   b How are the interests and personalities of animals considered in relation to aspects that go beyond animal welfare?
   c How are animal-perceived "voices" considered within concrete animal experiments?

Data availability statement

The datasets presented in this article are not readily available because the participants did not allow to share personal data to other researchers. Requests to access the datasets should be directed to KA, katharina.ameli@vetmed.uni-giessen.de.

Ethics statement

The studies involving human participants were approved by the Justus Liebig University Giessen. The study involving human participants was conducted in accordance with the European General Data Protection Regulations and with the Code of Ethics of the German Sociological Association.

Author contributions

KA: Writing – review & editing, Writing – original draft. SK: Writing – review & editing, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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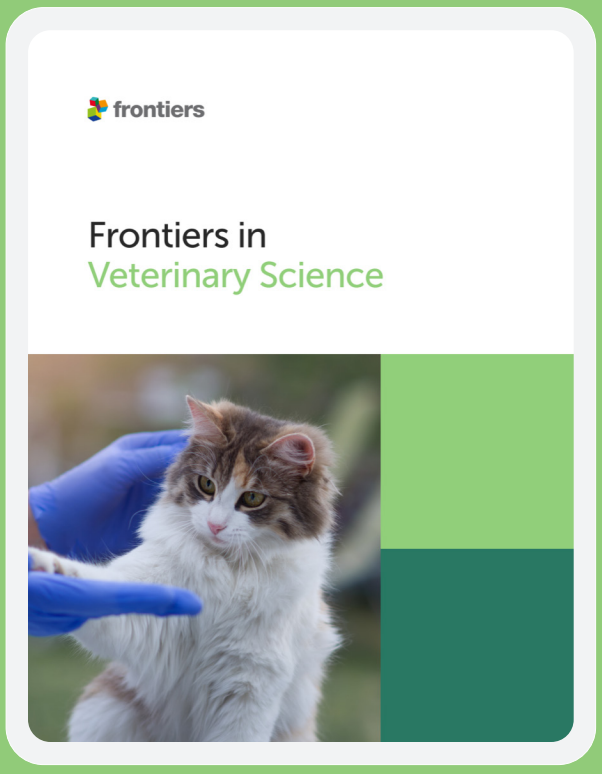

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