

**Universidade de Évora - Escola de Ciências e Tecnologia**

**Mestrado Integrado em Medicina Veterinária**

Dissertação

**One Health, One Training: The importance of the One Health Approach in Veterinary Training**

**Ema Barranhão Costa**

Orientador(es) | Catarina Lavrador

Filipa Ceia

Filipe Dias

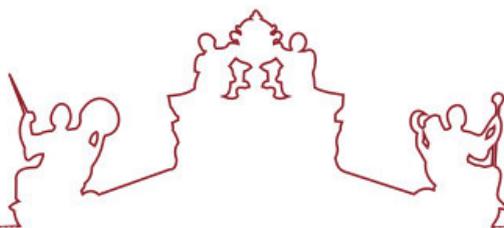
Évora 2026

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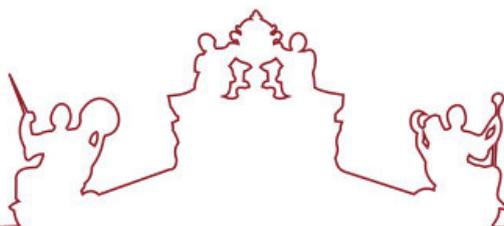
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A dissertação foi objeto de apreciação e discussão pública pelo seguinte júri nomeado pelo Diretor da Escola de Ciências e Tecnologia:

Presidente | Ricardo Jorge Romão (Universidade de Évora)

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## Abstract of dissertation

The One Health approach is gaining increasing relevance in global health promotion, underscoring the importance of its early integration into health professionals' education.

This dissertation examines the value of early One Health training through a veterinary medicine curricular traineeship conducted at a leading human medicine hospital and a One Health Research Institute.

A qualitative, observational, and descriptive methodology was adopted, based on direct participation, systematic observation, and the development of One Health–focused educational and data collection tools.

The traineeship enabled exposure to human clinical medicine, human and veterinary epidemiology, and antimicrobial stewardship across sectors. The findings suggest that transdisciplinary experiential learning enhances understanding and practical application of One Health principles, while fostering cross-sectoral collaboration skills.

This study concludes that integrating structured One Health traineeships into veterinary curricula strengthens multidisciplinary competencies and represents a reproducible educational model for other health-related training programmes.

Keywords: One Health Training, Health Education, Zoonoses, Antimicrobial Stewardship, Surveillance

# Uma Saúde, Uma Formação: A Importância da Abordagem Uma Saúde na Formação em Medicina Veterinária

## Resumo

A abordagem *One Health* está a ganhar cada vez mais relevância na promoção da saúde global, enaltecendo a importância da sua integração precoce na formação dos profissionais de saúde.

Esta dissertação analisa o valor da formação precoce em *One Health* por meio de um estágio curricular de medicina veterinária realizado num hospital de medicina humana e num Instituto de Investigação *One Health*.

Foi adotada uma metodologia qualitativa, observacional e descritiva, baseada na participação direta, observação sistemática e desenvolvimento de ferramentas pedagógicas e de recolha de dados com foco na abordagem *One Health*. O estágio permitiu a exposição à medicina clínica humana, epidemiologia humana e veterinária e gestão do uso de antimicrobianos em vários setores.

Os resultados sugerem que a aprendizagem transdisciplinar melhora a compreensão e a aplicação prática dos princípios *One Health*, enquanto promove competências de colaboração intersectorial.

Este estudo conclui que a integração de estágios estruturados *One Health* no *curricula* de estudos de medicina veterinária reforça as competências multidisciplinares e representa um modelo educativo reprodutível para outros programas de formação na área da saúde.

Palavras-chave: Formação Uma Só Saúde, Educação em Saúde, Zoonoses, Gestão Responsável de Antimicrobianos, Vigilância Epidemiológica

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## List of Abbreviations

AMR – Antimicrobial resistance

AMS – Antimicrobial stewardship

DGAV – Direção-Geral da Alimentação e Veterinária / Directorate-General for Food and Veterinary

ELIPSA – Establishment of Epidemic Panels for One Health Surveillance in Sub-Saharan Africa

EDUSHE – “Educação para Uma Só Saúde. Do Hospital para a Escola: colaboração para uma Saúde Global”/ “Education for One Health. From Hospital to School: Collaboration for Global Health”

EU – European Union

HAIs – Healthcare-associated infections

HIOH – Helmholtz Institute for One Health

IC – Infection Control

IDEAL - Infectious Diseases of East to African Livestock

IDD – Infectious Disease Department

IPC – Infection Prevention and Control

MERS-COV – Middle east respiratory syndrome coronavirus

MDRO’s – Multidrug resistant organisms

OH – One Health

OHS – One Health Surveillance

OHSJG – One Health São João Group

OHSJP – One Health São João Project

PPE – Personal Protective Equipment

SHIP – Study of Health in Pomerania

SOPs – Standard Operating Procedures

ULS São João – Unidade Local de Saúde/ Local Health Unit São João

UPCIRA – Unidade de prevenção e controlo de infeção e resistência aos antimicrobianos/  
Unit for Infection Prevention, Control and Antimicrobial Resistance

WHO – World Health Organization

WOAH – World Organisation for Animal Health

## Introduction

The One Health (OH) approach is a collaborative, multidisciplinary, and multisectoral strategy aimed at addressing health threats arising at the interface of human, animal, and environmental systems, with a core emphasis on balance and equity among all participating sectors and disciplines. The term appears for the first time in the 19<sup>th</sup> century linked to the term of “Zoonosis” and the interconnection between animal and human medicine (Barton Behravesh, 2019; Gyles, 2016; Winkler et al., 2025).

Over the past decade, this approach has gained momentum, marked by increasing commitment, recognition and support from a range of key international organisations, such as the World Organisation for Animal Health (WOAH), the World Health Organization (WHO), the Food and Agriculture Organisation (FAO) and United Nations Environment Programme (UNEP), that together represents the Quadripartite Organizations (FAO et al., 2022).

The Quadripartite drive the change and transformation required to mitigate the impacts of current and emerging global health challenges (FAO et al., 2022). In response to international calls to prevent future pandemics and to promote sustainable health through the OH approach, the Quadripartite developed the One Health Joint Plan of Action (OHJPA).

This Joint Plan of Action articulates the commitment of the Quadripartite to collectively advocate for and support the implementation of the OH approach. It builds upon, complements, and adds value to existing global and regional OH initiatives and coordination mechanisms, with the aim of strengthening capacity to address complex, multidimensional health risks and to enhance the resilience of health systems (FAO et al., 2022).

The European Union (EU) plays a complementary and supportive role, despite not being a formal member of the Quadripartite. It contributes to the implementation of OH principles primarily through regional coordination, policy alignment, and scientific cooperation.

This role is operationalised through mechanisms such as the EU Cross-agency OH Task Force, which brings together key European agencies to promote integrated approaches across all health sectors. Furthermore, the EU aligns its legislative and strategic initiatives with the priorities outlined in the OHJPA, thereby supporting the regional adaptation and implementation of global OH objectives.

At a national level, notable contributions have been made by important institutions including the Direção-Geral de Alimentação e Veterinária/ Directorate-General for Food and Veterinary (DGAV) and the Direção-Geral de Saúde/ Directorate-General of Health (Barton Behravesh, 2019).

This growing engagement reflects a shared objective: to promote a multisectoral, transdisciplinary, and collaborative implementation framework capable of a more effectively approach to global health threats at the human-animal-environment interface (Barton Behravesh, 2019).

Industrialisation, urbanisation and globalisation have generated an array of interlinked threats to health and wellbeing throughout the socioecological system (Winkler et al., 2025).

The impact of infectious diseases, non-communicable diseases and antimicrobial resistance (AMR) are increasing, climate change is accelerating, biodiversity is declining, and crisis of food insecurity and freshwater scarcity are progressing. These global threats pose a significant risk throughout the socioecological system which reflects on global economic instability and unsustainable development (Winkler et al., 2025; WHO, 2022).

Among the leading global health threats, zoonotic diseases and AMR rank within the top ten. Zoonotic diseases are responsible for an estimated 2.5 billion cases of human illness and 2.7 million human deaths annually (CDC, 2024).

Veterinary medicine holds a unique and vital contribution within the OH framework for the prevention and mitigation of global health threats.

Veterinary surgeons are the forefront of infectious disease detection and management, playing a critical role in early diagnosis and response. Hence 60% of human infectious diseases being of animal origin, many of these pathogens are initially identified and investigated within animal populations, underscoring thus the crucial role of veterinary professionals to public health and biosecurity (Barton Behravesh, 2019).

They work at surveillance and research of emerging and re-emerging zoonotic diseases across wildlife, domestic animals, and production systems, as well as in the study and monitoring of AMR, contributing through integrated surveillance systems and through its essential involvement in food safety and food security.

Furthermore, while promoting the health and welfare of companion animals, livestock, and wildlife, ranging from preventive medicine, which aims to reduce the incidence of infectious diseases, non-communicable diseases, and AMR, to clinical practice, veterinary surgeons also play a vital role in ecosystem preservation through the implementation and adherence of preventive measures within agricultural and production systems.

Given the wide scope of veterinary involvement across these critical domains, and the inherently multisectoral nature of their work, the education and training of veterinary surgeons should be strengthened by the four Cs of the OH framework, collaboration, communication, coordination and capacity building, across different sectors and disciplines.

To this end, this dissertation, grounded in the curricular traineeship of a veterinary student, underscores the importance of embedding OH principles into the education of veterinary students and on the professional development of veterinary practitioners. The traineeship was entirely based on a OH approach. It lasted a total of six months and was divided into two stages.

The first stage, lasting three months, took place at the Unidade Local de Saúde / Local Health Unit (ULS) São João, a public tertiary care-hospital for human health in Oporto, Portugal. The second stage also lasted three months and took place at the Helmholtz Institute for One Health (HIOH), a research institute in Greifswald, Germany.

The primary objective of the traineeship was to foster the development of a OH perspective, both professionally and personally. During the course at ULS São João, valuable insights were gained, allowing the comparison with similar procedures and decision-making approaches in veterinary medicine.

Among the various activities undertaken, the close observation of zoonotic cases, allowed for a deeper understanding of the multiple links between clinical presentations and symptoms, the host-animal relationship, the host's socio-economic background, and definitive diagnosis.

Knowledge was acquired regarding hospital practices for effective antimicrobial stewardship (AMS) and infection prevention and control (IPC). Participation in the project "From the Hospital to the School" highlighted the critical role of early education in health-related topics, particularly in promoting awareness of the OH concept from a young age.

The subsequent traineeship at HIOH, which included work contributions to the ELIPSA project (Establishment of Epidemic Panels for One Health Surveillance in Sub-Saharan Africa), further emphasized the vital role of veterinary professionals in research. It reinforced the essential nature of transdisciplinary and intersectoral collaboration.

This traineeship experience was both distinctive and innovative in its structure and practical experience, combining placements within a human healthcare setting and a cross-research institute. This dual setting effectively embodied the multisectoral and transdisciplinary nature of the OH framework.

This dissertation demonstrates the significance and impact of integrating the OH approach into the education and training of veterinary students. As a result of the traineeship, essential intellectual and professional competencies required for the future role of a veterinary surgeon have been deepened and developed.

Furthermore, it has reinforced the value of interdisciplinary and intersectoral collaboration not only as a means of sharing information and expertise, but also as a vital pathway for continuous learning and knowledge acquisition.

To address the objectives of this dissertation, the work is structured into three interrelated components. The first component provides a detailed account of the activities undertaken during the traineeships at ULS São João and HIOH.

The second component comprises a literature review focusing on animal health within the framework of the OH approach. This section explores several key areas such as preventive medicine, the critical role of four C's of OH, particularly in research, the global impact of zoonotic diseases and their transmission, the vital role of AMS and IPC in AMR, and the development of One Health Surveillance (OHS) systems.

The third component presents an empirical study focused on the development of OH-related materials and tools, outlining the process behind their creation.

The first developed tool addresses considerations for responsible and safe travel with companion animals. The second and third tools are infographics aimed at promoting AMS and infection control (IC) in veterinary medicine under a OH perspective.

Additionally, this third component also includes the development of data collection tools for the OH cohort study within the ELIPSA project, specifically the design of population questionnaires and the drafting of Standard Operating Procedures (SOPs) related to physical examinations and biological sample collection in animals.

The materials produced are intended not only as part of an ongoing learning process but also as practical tools for both clinical application and research within a OH context.

This dissertation highlights the important role of Veterinary Medicine within the OH framework, but most particularly, the importance of a OH based education strategy, and the knowledge and experience gained through a human health-focused traineeship and through research setting traineeship. By identifying key areas such as preventive medicine, AMS, IPC and zoonotic disease surveillance, this work underscores the importance of equipping future veterinary surgeons with the skills and perspectives necessary to contribute to sustainable, cross-sectoral and effective health strategies.

## Objectives and Methods

### 1. General Objective

The general objective of this dissertation is to analyse and demonstrate the relevance of the OH approach in veterinary education and professional training, through a multisectoral, transdisciplinary and collaborative traineeship experience conducted in human healthcare and research settings.

### 2. Specific Objectives

The specific objectives of this dissertation are to:

- a) Describe and critically reflect on the activities developed during the OH-based traineeship at the ULS São João and HIOH.
- b) Analyse the contribution of veterinary medicine to key domains, including preventive medicine, AMS, IPC, zoonotic disease surveillance and wider OHS.
- c) Compare approaches to disease prevention, diagnosis, IC, and antimicrobial use between human and veterinary medical settings.
- d) Evaluate the role of interdisciplinary and intersectoral collaboration in strengthening health systems and professional competencies within a OH framework.
- e) Develop practical OH-oriented tools and educational materials applicable to different contexts.
- f) Assess how exposure to a multisectoral and transdisciplinary training environment enhances the professional development of veterinary students.

## 3. Methods

### 3.1. Study Design

This dissertation adopts a qualitative, descriptive and exploratory approach, grounded in a six-month curricular traineeship based on the OH framework. The work integrates qualitative observational methods, literature review, and applied tool development, reflecting the multidisciplinary and practice-oriented nature of One Health education.

The dissertation is structured into three complementary components:

1. Description and analysis of traineeship activities;
2. Narrative literature review;
3. Development of OH-oriented educational and research tools.

### 3.2. Traineeship Settings

The traineeship was conducted over a total of six months and divided into two stages:

1. First stage (three months): ULS São João, Porto, Portugal — a public tertiary care hospital in a human healthcare setting.
2. Second stage (three months): HIOH), Greifswald, Germany — a research institute focused on interdisciplinary OH research.

These two settings were intentionally selected to provide exposure to both different health settings, enabling a comparative and integrative learning experience.

### 3.3. Traineeship Activities and Data Collection

During the traineeship, data were collected and deepened through:

- a) Participant observation of clinical, laboratory, surveillance, and research activities.
- b) Direct involvement in multidisciplinary teams, meetings, and project-related tasks.
- c) Critical reflection on observed practices related to zoonotic disease management, AMS, IPC, and public health interventions.
- d) Documentation of activities, including field notes and other institutional materials.

At ULS São João, activities focused on:

- a) Observation of zoonotic disease cases;
- b) Hospital infection prevention and control measures;
- c) Antimicrobial stewardship practices;
- d) Participation in health education initiatives, including the project “*From the Hospital to the School*”.

At HIOH, activities included:

- a) Contribution to the ELIPSA project;
- b) Participation in One Health research discussions and interdisciplinary collaboration;
- c) Development of surveillance-related tools and protocols.

### 3.4. Literature Review

A narrative literature review was conducted to contextualise the traineeship experience within the OH framework. Scientific articles, reports, and guidelines from international organisations (WHO, FAO, WOA, UNEP), peer-reviewed journals, and official institutional documents were consulted.

The literature review focused on:

- a) Preventive medicine within OH;
- b) Zoonotic diseases and their global impact;
- c) Antimicrobial resistance, AMS, and IPC;
- d) The four Cs of OH (collaboration, communication, coordination, capacity building);
- e) Development and implementation of OHS systems.

### 3.5. Development of One Health Tools and Materials

As part of the empirical component of this dissertation, several OH-oriented tools were developed, including:

- a) Educational materials promoting responsible and safe travel with companion animals;
- b) Infographics addressing AMS and IC in veterinary medicine;
- c) Data collection instruments (population questionnaires) and drafting of SOP's for animal physical examinations and biological sample collection for ELIPSA project.

The development of these materials was informed by direct observations made during the traineeship activities, as well as by a targeted review of the relevant scientific literature and international guidelines conducted throughout the traineeship period.

The materials developed during the traineeship at ULS São João were validated by the One Health São João Group and subsequently disseminated through the official website of ULS São João, by the One Health Working Group of DGAV and the Petabook platform.

Regarding the materials developed during the traineeship at HIOH, validation occurred at different stages of the development process, and the final materials were subsequently implemented in field activities within the scope of the ELIPSA project.

### 3.6. Ethical Considerations

All activities were conducted in accordance with institutional guidelines and ethical standards. No direct clinical interventions or experimental procedures were performed by the trainee. Contributions to research projects were developed under supervision and followed established ethical and data protection protocols.

### 3.7. Methodological Limitations

This dissertation is based on a traineeship experience and therefore does not aim to generate statistically generalisable results. Instead, it provides an in-depth, contextualised analysis of OH training through experiential learning. Nevertheless, the diversity of settings and activities strengthens the relevance and transferability of the insights obtained.

## PART I - Description of the Activities Carried Out During the Traineeship

### 1. The Traineeship at Local Health Unit (ULS) São João

The curricular traineeship lasted six months and was composed of two stages, as previously mentioned. The first component lasted three months, starting in September 2024 and ending in December 2024, at the ULS São João. The second period also lasted three months, beginning on January 2025 and concluding on April 2025, at the HIOH in Germany.

During the first component of the traineeship, various tasks were carried out. To provide context regarding the ULS São João and its operations, a brief description of the institution's functions and organizational structure will be presented. This will be followed by a summary of the activities undertaken during the traineeship at ULS São João. A detailed description of the fields in which activities were conducted will be provided in PART II, Chapter V.

#### 1.1. Operational Framework of the ULS São João

The ULS São João, a tertiary-care teaching hospital located in the city of Oporto, is structured into three main domains: clinical service areas, clinical support areas, and general support services. Its mission is to deliver high-quality human healthcare at both national and international levels, while fostering sustainable development. Additionally, the institution is committed to the advancement of education and research, supporting both undergraduate and postgraduate training programmes.

The One Health São João Group (OHSJG) was formally established in 2023, after having been active since 2019, with the mission of fostering interdisciplinary collaboration, promoting education and training and advancing integrative research in OH.

A pioneer in implementing OH initiatives from within a tertiary hospital setting, its objectives include disseminating of OH concept within the hospital, academic and wider community, preparing current and future professionals to apply this approach in practice, and strengthening diagnostic capacity and surveillance of zoonotic diseases in order to address emerging health challenges.

To fulfil this mission, the hospital relied on the dedication of a highly motivated group of professionals from the Infectious Disease Department (IDD), including both nurses and physicians.

Currently, the IDD demonstrates recognized expertise in AMR, healthcare-associated infections (HAIs) - especially those caused by multidrug-resistant organisms (MDROs) and those related to medical devices, infections in immunocompromised hosts, imported tropical pathologies (particularly among travellers and migrants), endemic zoonosis and emerging infectious diseases.

Due to their significant impact on public health, the so-called emerging infectious diseases necessitate prompt and robust diagnostic interventions, clinical surveillance, public health monitoring, and the implementation of educational and preventive strategies.

Consequently, the field of infectiology remains the forefront of health protection, spanning environmental, animal, and human domains, thereby embodying the OH approach.

In fact, the *One Health São João project (OHSJP)* is an initiative of the IDD team. This working group operates within the framework of the OH approach and focuses on three key areas: providing technical consultancy to ULS São João staff, broader educational actions, and scientific research, all aligned with the principles of the OH framework.

Based on the imperative of intersectoral collaboration in OH, and reflecting the commitment of the OHSJG to education in this domain, interdisciplinary traineeships have constituted a core component of the strategic plan of the OHSJP since its inception.

These traineeships are intended to be comprehensive across the disciplines involved. Due to the technical proximity and the similarity of activities carried out with human health professionals, Veterinary Medicine was the first field of knowledge for which it was possible to design and implement a traineeship programme.

The fundamental pillars of the traineeship programme include zoonosis, zoonotic risk in immunocompromised hosts, zoonotic risk in travel medicine and migrants' health (both for human and animal hosts), antimicrobial rational use and resistance prevention, and IPC.

All these pillars are addressed from a practical and cross-disciplinary perspective.

Therefore, in addition to having closely observed and acknowledged the activities undertaken within the IDD, the trainee was also afforded the opportunity to observe and engage with the work conducted by Unidade de prevenção e controlo de infeção e resistência aos antimicrobianos/Unit for Infection Prevention, Control and Antimicrobial Resistance (UPCIRA) at ULS São João.

As highlighted by organisations such as the Centre for Disease Control and Prevention (CDC), European Centre for Disease Prevention and Control (ECDC) and WHO, among the most pressing global health threats is AMR, and is projected to become the leading cause of mortality by 2050.

Furthermore, in response to growing international concern regarding HAIs and MDROs, the WHO outlined strategic measures to mitigate the emergence and transmission of MDROs.

Moreover, Portugal is one of the (European) countries with the highest prevalence of HAIs and consumption of antibiotics, particularly carbapenems and quinolones (ECDC, 2023).

Because of the high concern about AMR, it was established in 2013 in Portugal, as a national priority initiative, a programme that encompasses surveillance, IPC activities, alongside the development of antimicrobial prescription assistance programmes, also called AMS programmes, the National Programme for the Prevention and Control of Infections and Antimicrobial Resistance (PPCIRA).

The primary objectives of the PPCIRA are to reduce the incidence of HAIs, promote AMS, and curb the prevalence of MDROs.

At the local level, the programme is operationalised through the Local Units of the Infection Prevention and Control and Antimicrobial Resistance Programme (Unidades Locais do PPCIRA – UL-PPCIRA), which are embedded within healthcare institutions of the National Health Plan. The UPCIRA team is responsible for coordinating and implementing such measures.

## 1.2. Traineeship Experience and Practical Involvement – ULS São João

The trainee was introduced to the core pillars of the traineeship from the very beginning, which allowed the structured organisation and full implementation of the intended activities. Continuous supervision and monitoring were provided by various healthcare professionals from the OHSJG, including physicians and nurses, enabling a balanced integration of observational training activities, primarily clinical in nature, with both tutored and independent learning experiences.

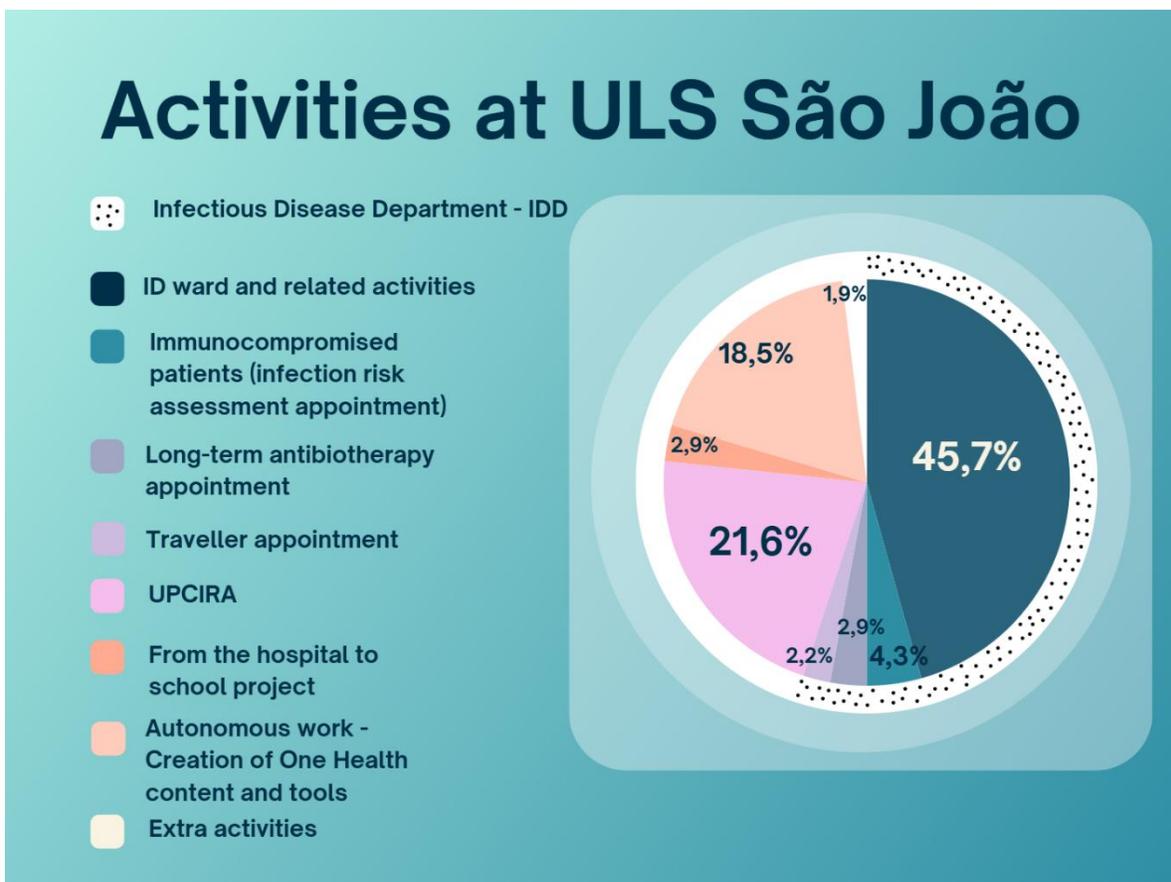
During the traineeship at ULS São João the following activities were undertaken:

- a) Observation and familiarisation with the practices and responsibilities of OHSJG members, the IDD team and the UPCIRA team;
- b) Participation in weekly scientific meetings in the field of infectious diseases;
- c) Observational monitoring of hospitalised patients due to zoonotic infections, alongside their epidemiological investigation;
- d) Supervised learning on hospital IC techniques and their adaptation for use in veterinary medical care settings;
- e) Shadowing medical consultations focused on Immunomodulation and Infection Risk, particularly in patients with elevated zoonotic exposure;
- f) Shadowing medical appointments involving long-term antibiotic therapy in patients with complex infections, particularly device-associated infections;
- g) Shadowing and gaining familiarity with the traveller's consultation, with particular emphasis on the elevated risk of acquiring vector-borne diseases and other zoonoses, and on the corresponding preventive strategies;
- h) Creation of a OH-based traveller's guide, in the context of traveller's consultation, entitled *Guide to Travelling with Your Pet*;
- i) Participation in the institutional outreach project *From the Hospital to the School*, involving preparatory meetings and the delivery of awareness-raising sessions at public schools, aimed at promoting early understanding of the OH concept among young students.

- j) Follow-up of AMS programmes and participation in multidisciplinary meetings for the discussion of complex infection cases in hospitalised patients;
- k) Development of educational infographics on AMS in veterinary medicine, framed within the OH perspective, with the titles: *Rational Use of Antimicrobials and Infection Control with a One Health Approach in Companion Animals*, and *Strategies on Farms: Rational Use of Antimicrobials and Infection Control in Production Animal Clinics*, both produced in the context of activities carried out with the UPCIRA team (Graphic 1).

The production of these contents is going to be thoroughly explained in PART III.

In addition to these core activities, the trainee observed the regular work in the in-patient ward and intensive care unit of IDD, as well as in other hospital departments with inpatients following the scope of the traineeship, particularly those with zoonotic diseases.



Graphic 1 - Activities at ULS São João

During the traineeship at ULS São João, participation in several scientific symposia was undertaken, encompassing both human and veterinary medicine, consistently approached from a OH perspective, approaching topics as migratory flows, multidrug-resistant bacterial infections, endemic fungal diseases, parasitic infections and microbiological research and biodiversity within aquatic ecosystem.

### 1.3. Other Activities

It was also provided the opportunity to participate in some interviews conducted by *Jornal Expresso*, *Universidade de Évora* and *Revista Veterinária Atual*. In these interviews, details regarding the traineeship were shared, including its structure, objectives, and origins. The interview served as an important platform to raise awareness of the importance of a OH-based education through this type of OH traineeship, encouraging the development of similar opportunities for other students across various health disciplines. Through such initiatives, the promotion of health in an integrated manner, for humans, animals, and the environment, is further advanced.

## 2. The Traineeship at Helmholtz Institute for One Health (HIOH)

The second component of the curricular traineeship, with a duration of three months, was undertaken at HIOH in Greifswald, Germany. During this period, a variety of tasks and responsibilities were carried out.

To provide context regarding HIOH and its institutional role, a brief overview of its structure and core activities will first be presented, followed by a summary of the tasks performed during the traineeship at this host institution. A detailed description of the ELIPSA project, in which active participation took place, is provided in PART II, Chapter VI.

### 2.1. Operational Framework of HIOH

#### 2.1.1. *The Helmholtz Association and the Helmholtz Centre for Infection Research*

The Helmholtz Association represents the largest scientific organisation in Germany. Research conducted across its 18 independent research centres and 12 Helmholtz Institutes aims to address the most pressing challenges facing society, science, and the economy.

The organisation is dedicated to developing sustainable, future-oriented solutions through a comprehensive research approach that spans the entire continuum from fundamental to application-driven science.

An inherently interdisciplinary methodology underpins its work. The Helmholtz Association collaborates closely with leading national and international research institutions and upholds the highest standards in talent development and the promotion of early-career researchers at all levels.

The Helmholtz Centre for Infection Research (HZI) is one of the Association's key institutions, dedicated to investigating the biological mechanisms underlying infectious diseases and host defence. Research outcomes are systematically translated into potential medical and pharmaceutical applications.

HZI's research advances the understanding of infection mechanisms and facilitates the development of innovative, personalised approaches for diagnosis, prevention, treatment, surveillance and control of infectious diseases, often in collaboration with industry partners.

HIOH, one of the several HZI's infrastructures and the host institution of the traineeship, broadens the existing research portfolio by placing a dedicated focus on the OH concept - recognising the interconnectedness of human, animal, and environmental health (HZI Helmholtz Centre for Infection Research, 2025).

### *2.1.2. HIOH – Helmholtz Institute for One Health*

At HIOH in Greifswald - a site of HZI - a transdisciplinary model for OH research has been implemented. The institute is dedicated to investigating the threats posed by both novel and established pathogens, as well as by AMR.

These investigations are conducted through comprehensive, longitudinal sampling and systematic data collection and analysis at the interfaces of human, animal, and environmental health, particularly with respect to emerging pathogens and resistance dynamics.

The foundation of HIOH's research strategy lies in the development and implementation of OHS across designated indicator regions, which serves as the core infrastructure for its scientific inquiry (Helmholtz HIOH, 2025).

### *2.1.3. The Work at HIOH*

Within this framework, HIOH's OHS Core Unit establishes a unique infrastructure for a systematic data collection, namely biological samples and data related to human, animal, and environmental health.

The OHS Core Unit serves as a unifying foundation, supporting the institute's research groups by systematically collecting long-term data, much like a meteorological station.

The OHS Core Unit brings together clinical monitoring of human health (in cooperation with human hospitals), continuous wildlife monitoring, e.g. of wild apes in sub-Saharan Africa, and the long-term observation of high-risk human populations with frequent animal contact, accompanied by parallel sampling of their respective livestock. Simultaneously environmental and climatic data are collected to enable a comprehensive understanding of health-related ecological interactions.

The surveillance efforts are currently concentrated in two key model regions: the African Tropics, specifically Ivory Coast and the Central African Republic, identified as hotspots for disease emergence and AMR, in collaboration with long-standing regional partners; and Europe, with a focus on Mecklenburg-Western Pomerania, where existing cohort studies and local projects such as SHIP, MuSPAD, and NAKO provide a strong foundation (Figure 1).



Figure 1 - Multidisciplinary in two key model regions: African Tropics and Europe - Source: HIOH

The Study of Health in Pomerania (SHIP) is a population-based epidemiological initiative. Its principal aims include determining the prevalence and incidence of common health risk factors, subclinical conditions, and diseases, while also investigating their complex interrelationships and long-term outcomes.

The SHIP is being developed in the region where HIOH is located and has recently been expanded to include an animal health module, now referred to as SHIP One Health.



*Figure 2 - Closed cooperation with long-standing partners - Source: HIOH*

A long-standing track record in international and interdisciplinary collaboration, along with a robust network of local and global partners, has enabled HIOH to effectively implement long-term OH monitoring (Figure 2).

In alignment with sustainable development principles, efforts are continuously made to strengthen local capacities and knowledge and expertise transfer to regional stakeholders (Helmholtz HIOH, 2025).

These activities are significantly strengthened by embedding the HIOH in the existing network of internationally recognized founding institutions.

The quality, quantity, and diversity of integrated data generated by HIOH provide a new mechanistic understanding of what perturbations are caused by what changes in individual parameters, therefore opening opportunities to better control the spread of dangerous microbes in the future.

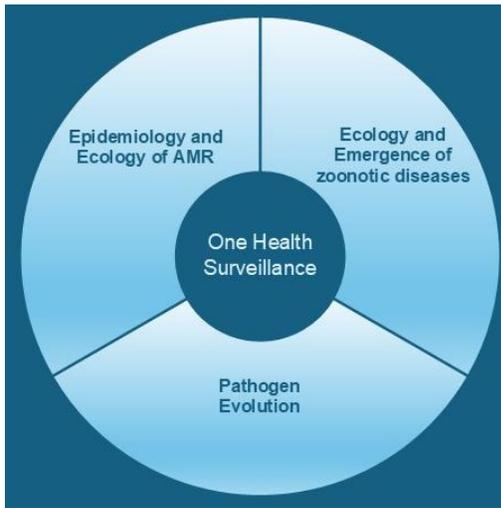


Figure 3 - Research Departments at HIOH

The institute's scientific programme is supported by three dedicated research departments, each focusing on: (1) the ecology and emergence of zoonotic diseases; (2) the epidemiology and ecology of AMR; and (3) pathogen evolution (Figure 3).

There are pillar-projects, which are called seed grants, and they help establish the OHS Core Unit (Figure 4). Some examples of these seed grants are the ELIPSA project on the development of One Health cohorts in Sub-Saharan Africa; the PanCo project – integrating One Health aspects into existing cohort studies in Germany; the ScienCe project – a project implementing clinical surveillance of human health in Ivory Coast and Central African Republic; the WiMoPOH project – a project in wildlife monitoring in Western Pomerania; the Ebio project – a project on environment monitoring and the InnoDia project – a project related to the development of standardized diagnostic pipelines for all the different types of samples that are part of One Health Surveillance.

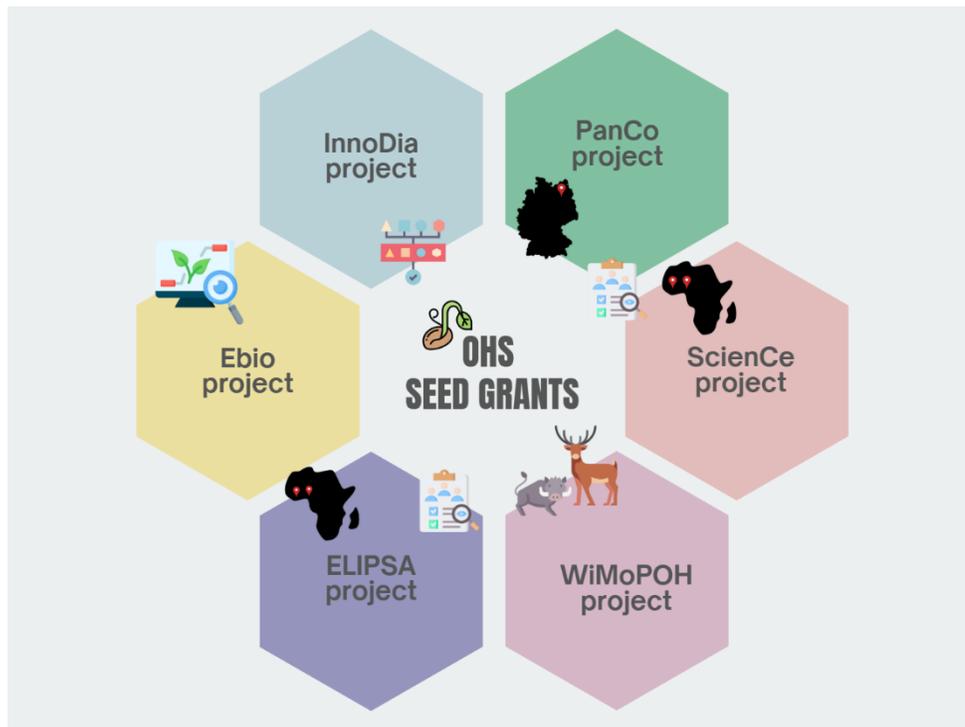


Figure 4 - OHS Seed Grants

## 2.2. Traineeship Experience and Practical Involvement - HIOH

Given the trainee's academic background in veterinary medicine and the perspective gained from her prior traineeship within a OH framework, provided the trainee with the necessary skills to collaborate with the OHS Core Unit team, specifically and meaningfully contributing to the ELIPSA project. A comprehensive description of this cohort study is provided in PART II, Chapter VI.

The activities undertaken as part of ELIPSA included the development of questionnaires aimed at communities involved in the cohort study, focusing on aspects of animal health.

In addition, SOPs were drafted for the physical examination of domestic animals within these communities, as well as for the collection of biological samples from the animals involved in the cohort. The development process of such tools is explained in *PART III*.

To successfully carry out these tasks, extensive interdepartmental and inter-institutional collaboration was required. This included meetings with the Data Management Department, discussions with researchers affiliated with the other crucial projects, such as Innodia project, collaborative sessions with scientists from the Friedrich-Loeffler-Institut (FLI), both online and in-person meetings with PhD students in Epidemiology from HZI campus in Braunschweig, and regular weekly meetings with Doctor Filipe Dias, the researcher responsible for the ELIPSA project. A final presentation of the work was delivered to the entire department, including the Head of Department.

Furthermore, attendance was granted at the institute's weekly seminars, during which twelve lectures covering a broad range of research topics and projects at HIOH were delivered by various researchers and doctoral students.

In this institute's weekly seminars there was an opportunity to deliver a presentation about the trainee's work in the context of the ELIPSA project, entitled "Development of Tools for the ELIPSA Project: Questionnaires and SOPs for Animal Health Monitoring" (Figure 5).



*Figure 5 - Presentation of the ELIPSA Project: Creation of Questionnaires and SOP's for Animal Health Monitoring*

Participation in the institute’s journal club was also undertaken. This monthly meeting, organised by and for PhD students, involves the selection and presentation of a scientific publication by one member, followed by a group discussion. A scientific article was presented, a paper by Mohamed Shaheen (2022), titled “ The concept of One Health applied to the problem of zoonotic diseases”.

### 2.3. Extra activities

As mentioned already, at HIOH, the researchers work in challenging topics related to human health, animal health and environment, such as diseases of zoonotic origin, AMR, the habitat changes and their impact on human health and the evolution of pathogens.

In this traineeship, was provided the space to gain deeper insight into the work conducted by the various research groups, as well as to become familiar with several of their ongoing projects. In addition, exposure was afforded to the Innodia project, one of the seed grant initiatives supported by the OHS Core Unit.

The **AMR research group**, includes not only the identification and classification of classical resistances and their epidemiological evaluation, but also the in-depth investigation of bacterial virulence and fitness factors, such as the formation of bacterial biofilms, as well as the establishment of alternative therapeutic strategies. With the help of genotypic and phenotypic experiments as well as functional and phylogenetic genome and transcriptome analyses, their primary goal is to analyse, better understand and ultimately combat successful pandemic pathogens.

The **ciFly** is a citizen science project, involving students and focused on the monitoring of AMR and mammal biodiversity by flies. The main goal of the project is to develop and subsequently evaluate an educational strategy that incorporates the OH approach and scientific research and its implementation into the *curricula* of a local high school in the western Pomeranian region of Germany. This project was designed as a sustainable citizen science project, encouraging students to critically think about the impacts of urbanization and agriculture on the prevalence of AMR and the biodiversity of wild mammals.

In collaboration with researchers from HIOH, the students develop monitoring systems based on environmental DNA from flies, leaf swabs and water to assess wildlife and AMR in their region. Flies serve as biological samplers of DNA derived from wildlife and bacteria.

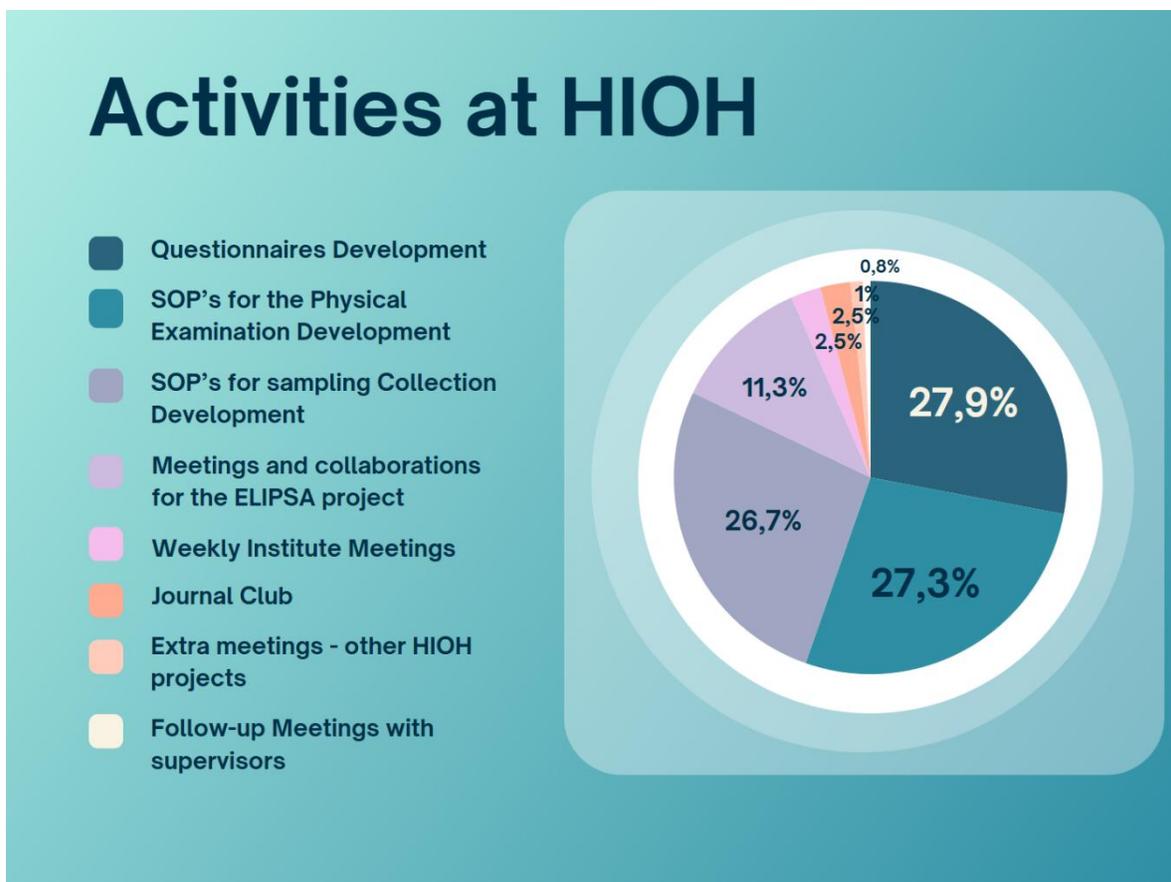
The primary objectives of the project are to enhance students' critical thinking skills related to scientific inquiry, introduce them to the core principles of the OH concept, and facilitate the generation of meaningful scientific data (Eberhard, 2024).

The **BCOMING project** has as main goal to collaboratively develop innovations with stakeholders in biodiversity hotspots aimed at mitigating the risk of infectious disease emergence through biodiversity conservation, disease surveillance strategies, and a deeper understanding of the mechanisms linking biodiversity to the risk of infectious diseases.

The activities of the project are implemented in Europe and three tropical biodiversity hotspots in Southeast Asia, West Africa and the Caribbean.

The **InnoDia project** (Innovative Diagnostic Pipelines for One Health Surveillance), is part of the development of an OHS Platform, as a seed grant. This is anchored at HIOH and will enable the long-term collection of data on the health of humans, animals and ecosystems in defined indicator regions (Taï National Park, Ivory Coast, Dzanga - Sangha Protected Areas, Central African Republic and Western Pomerania). The OHS Core Unit will implement comprehensive sampling designs at the interfaces between humans, domestic animals, wildlife and the environment that will allow researchers to decipher the temporal dynamics of pathogen transmission within and between host species and to identify drivers of outbreaks, spillover effects and the changing distribution of AMR in complex landscapes.

The graphic below outlines the structure of all activities undertaken during the traineeship at HIOH, along with the time allocated to each (Graphic 2).



Graphic 2 - Activities at HIOH

## PART II – Literature Review – Veterinary Medicine as a Natural and Integral Part of the One Health Approach

### 1. Chapter I - Introduction to the One Health Concept

The One Health concept, depending on the foundational perspective and disciplinary approach, has also been associated with or referred to by related terms such as “One Medicine”, “One Medicine-One Health”, “One World-One Health”, “EcoHealth”, and “Planetary Health” (Pettan-Brewer et al., 2021).

Born and evolved from the concepts of “One Medicine”, “One Medicine-One Health”, first generated by Rudolf Virchow, a 19th century physician and pathologist and latter from Dr. Calvin Schwabe ( Barton Behravesh, 2019; Pettan-Brewer et al., 2021; Winkler et al., 2025) to the ‘One Health’ concept has emphasised the fact that it should be a priority promote health starting with prevention, rather than focusing solely on treatment (Gyles, 2016).

Realising the full potential of the OH approach requires a deepening interdisciplinary and transdisciplinary understanding of the fundamental interconnectedness and health interdependencies among humans, other animals, plants, and a myriad of other biotic and abiotic elements in the ecosystem (Winkler et al., 2025).

Only through such comprehensive integration - supported by a multisectoral approach to fostering healthy socioecological systems - can OH be meaningfully operationalised to address the urgent global health and sustainability challenges of contemporary times (Gyles, 2016; Winkler et al., 2025).

The One Health High-Level Expert Panel (OHHLEP), established by four key international organisations, Food and Agriculture Organisation (FAO), United Nations Environment Programme (UNEP), WHO, and WOAHA - brings together experts across a wide range of scientific and policy domains relevant to the OH framework. This panel has developed a formal operational definition of OH, which is cited as follows:

*“One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems.*

*It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent.*

*The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development.”*

(Tripartite and UNEP Support OHHLEP’s Definition of One Health, 2021) (Figure 6).

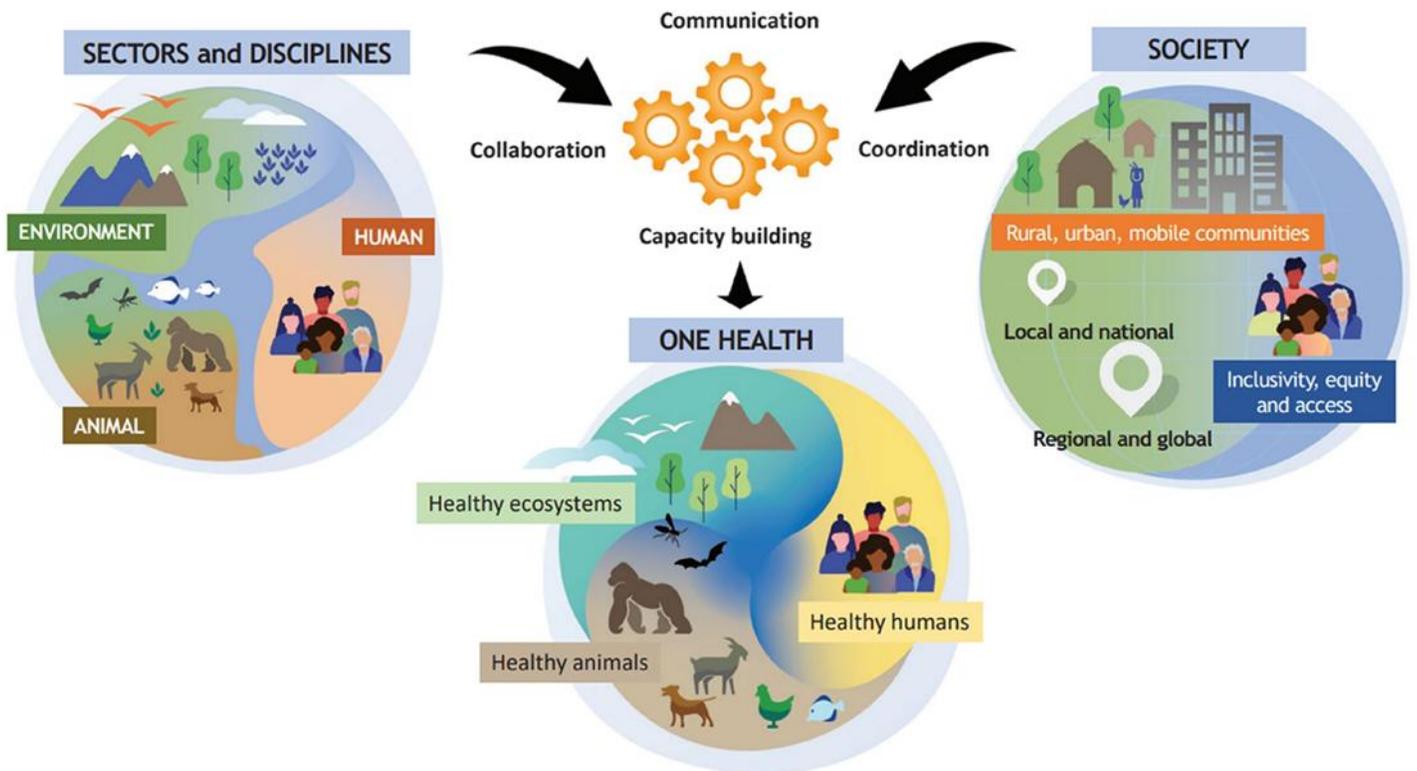


Figure 6 - OHHLEP One Health definition visual from (Mettenleiter et al., 2023)

The primary challenges addressed within the OH framework are written in the (Figure 7).

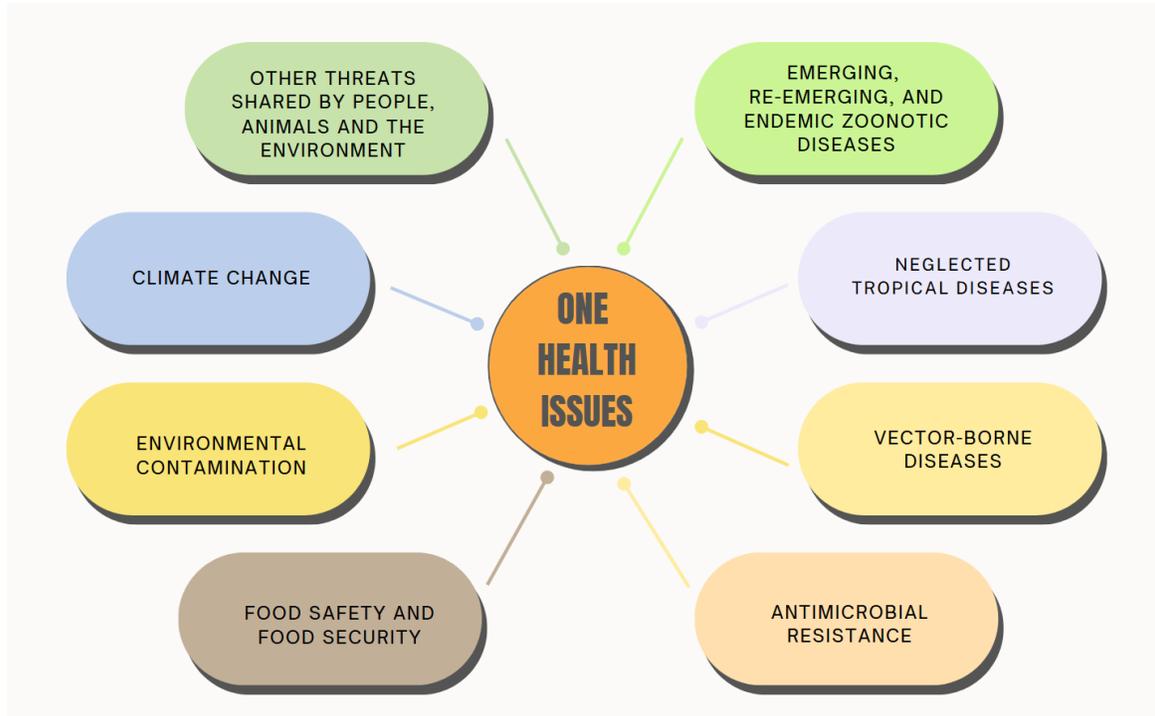


Figure 7 - The main challenges within the One Health framework – Adapted from: (CDC, 2024)

Therefore, OH approach represents a collaborative, multidisciplinary, and multisectoral strategy aimed at addressing current, emerging, and potential health threats arising at the interface of human, animal, and environmental systems. It operates across subnational, national, regional, and global levels, with a core emphasis on balance and equity among all participating sectors and disciplines (Barton Behraves, 2019; Winkler et al., 2025).

In alignment with this perspective, effectively managing health threats at the human–animal–environment interface necessitates coordinated action across sectors, disciplines, and communities.

The term *multidisciplinary* refers to the collaboration of experts from various fields, such as researchers, physicians, nurses, veterinary surgeons, and epidemiologists, while *multisectoral* implies the involvement of multiple sectors. However, multisectoral collaboration does not necessarily ensure the participation of all relevant stakeholders.

Although, adopting a OH approach entails the active and inclusive engagement of all pertinent sectors and disciplines, including public health, veterinary medicine, and environmental science, as well as communities worldwide.

Only through such inclusive collaboration can mutual trust be established, roles and responsibilities clearly defined, and shared goals, priorities, and objectives effectively developed.

## 2. Chapter II – Veterinary Preventive Medicine in a One Health Approach

Over the past few decades, the incidence of transboundary and emerging animal diseases has been on the rise and a necessity of a OH approach to prevent and mitigate harmful health outcomes is highlighted (AnimalhealthEurope, 2025a; Winkler et al., 2025).

Global trade, the increasing speed and frequency of international travel, the expanding range and persistence of disease vectors, and, at times, conflicting animal health and trade policies collectively contribute to an elevated risk and amplified impact of animal disease outbreaks, including their potential transmission, or spillover, to human populations (Winkler et al., 2025).

In 2024, a reactive approach to disease prevention demonstrated relative effectiveness, owing to the pre-existence of vaccines for avian influenza and prior industry familiarity with the bluetongue virus serotype BTV-3. However, no vaccines were immediately available during the outbreak in the Netherlands. In response, the animal health sector rapidly mobilised to develop and distribute the required vaccines, thereby mitigating the outbreak's impact on European agriculture. Nonetheless, questions remain as to whether this reactive model constitutes the most effective strategy for future outbreak prevention (AnimalhealthEurope, 2025a).

These challenges are further exacerbated by climate change, as rising temperatures and altered precipitation patterns influence the emergence and geographical spread of diseases across the globe (AnimalhealthEurope, 2025c; Winkler et al., 2025).

Exclusive reliance on reactive strategies may prove insufficient in safeguarding Europe’s animal populations, and potentially human health, from future, and likely inevitable, disease outbreaks (AnimalhealthEurope, 2025a).

A fundamental paradigm shift is necessary—transitioning from a reactive, crisis-oriented approach to one that prioritises proactive prevention. Adopting a OH perspective, health promotion and disease prevention must be afforded equal importance to curative medicine, while fostering population-wide literacy in health and sustainability is essential for long-term resilience (Winkler et al., 2025).

In the absence of such a transition, future outbreaks risk escalating rapidly, with potentially severe consequences for European agriculture, public health, and the wider economy (AnimalhealthEurope, 2025a).

Outlined below are four key recommendations to consider in order to prioritise a preventive, rather than reactive, approach to animal health and preventive medicine (Figure 8).



Figure 8 - Preventive Medicine in Animal Health – “fire-prevention” points - Adapted from: (AnimalhealthEurope, 2025c)

Safeguarding animal health and avoiding large-scale culling events should be central priorities for policymakers within the European Union.

Animal diseases, particularly those associated with high morbidity or mortality, can have far-reaching consequences, extending beyond animal welfare to impact food security and affordability, the socio-economic resilience of Europe's farming communities, the prudent use of antimicrobials, farmers' mental health, and public health more broadly.

For endemic diseases, existing surveillance data may enable approximate forecasting of disease risk and potential impact, providing a valuable basis for continuous dialogue between the animal health sector and regulatory authorities (AnimalhealthEurope, 2025a).

In the context of emerging diseases, the existence of such a framework would considerably enhance Europe's capacity to prepare for and respond to health emergencies.

## 2.1. Vaccination

Vaccination remains one of the most effective interventions for disease prevention in both veterinary and human medicine. Indeed, investment in animal vaccination for the control, prevention, and elimination of zoonotic diseases represents a compelling example of a cost-effective OH approach. (Gomes, 2021; Winkler et al., 2025).

Despite certain limitations, vaccination has proven to be a cornerstone of public health (animal and human health), ultimately leading to the global eradication of smallpox and laying the foundation for immunisation programmes targeting a wide array of infectious diseases in both humans and animals (McVey & Shi, 2010).

As an example, Louis Pasteur made seminal contributions to the field of immunology by developing vaccines for various animal diseases, including fowl cholera (1879), anthrax (1881), rabies (1885), and swine erysipelas (1892) (Gomes, 2021; McVey & Shi, 2010).

There is robust evidence supporting the critical role of widespread vaccine use in global eradication of infectious diseases, such as poliomyelitis in humans, and also in the regional control of important infectious diseases in animal domain such as foot-and-mouth disease (FMD) and rabies (McVey & Shi, 2010).

In the 1950s, the introduction of vaccines for companion animals, such as dogs and cats, led to a marked reduction in the incidence of diseases including distemper, parvovirus, rabies, canine infectious hepatitis, and feline panleukopenia, among others (Day et al., 2016).

A preventive approach should be equally emphasised in veterinary medicine as in human healthcare. The prevention of disease in animals not only alleviates suffering and reduces premature mortality, but also supports healthy development and mitigates the risk of zoonotic transmission (AnimalhealthEurope, 2025b).

Veterinary preventive medicine encompasses not only vaccination but also the education and engagement of animal owners. Raising awareness about risk-related behaviours in animals and providing guidance on how to mitigate them represents an important component of disease prevention. From a OH perspective, such measures contribute not only to animal health but also to the wellbeing of owners and the broader community.

When appropriately administered, vaccines can protect animals from infection or reduce the transmission and severity of disease, thereby lowering the risk of large-scale outbreaks. As in humans, animal vaccination plays a vital role in safeguarding health prior to disease onset, ultimately improving animal welfare (AnimalhealthEurope, 2025b).

A notable example of infectious disease prevention is rabies, which will be examined in greater detail in Chapter V. Achieving high vaccination coverage among canine populations has been demonstrated to be a cost-effective and highly efficacious strategy for the prevention, control, and potential elimination of dog-mediated human rabies, given that dogs remain the principal reservoir and vector of transmission in numerous regions. (WOAH, 2025b; Winkler et al., 2025).

### *2.1.1. Benefits of Vaccination*

Disease prevention through vaccination plays a critical role in protecting the health of both animals and humans. It also contributes to economic resilience, promotes the responsible use of antimicrobials, and supports sustainable practices in animal production (AnimalhealthEurope, 2025b).

Outlined below are several key benefits associated with animal vaccination (Figure 9).

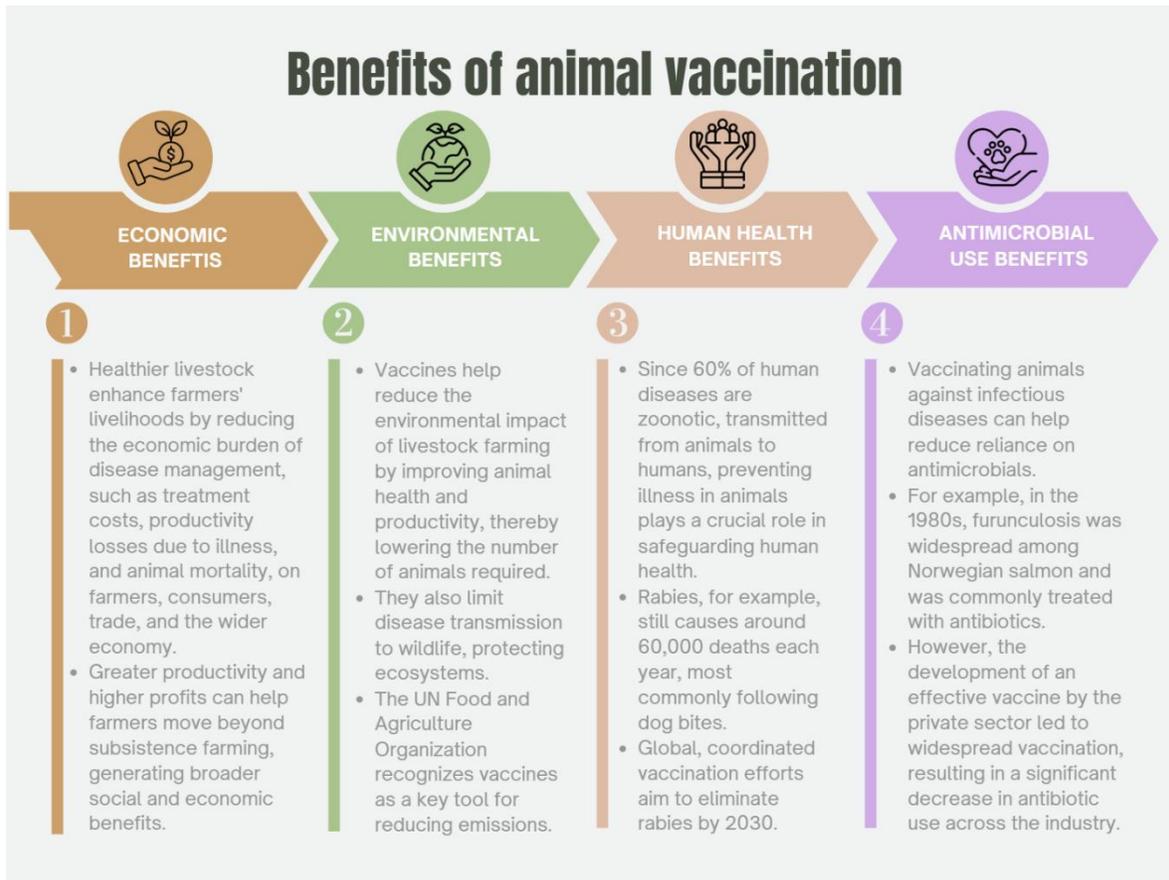


Figure 9 - Benefits of animal vaccination - source: (Health For Animals, 2021)

A more coordinated and collaborative partnership, underpinned by the principles of the 3Rs (Replacement, Reduction, and Refinement), could enhance the industry's capacity to anticipate vaccine requirements and strengthen preparedness for the management and prevention of foreseeable disease outbreaks. Such an approach would also contribute to addressing increasing public concern regarding mass culling practices (AnimalhealthEurope, 2025c).

### 2.1.2. Barriers to Vaccination

The need for animal vaccines is greater than ever. However, global uptake remains suboptimal. This is primarily due to a set of six interrelated barriers, reflecting a complex array of contributing factors (Figure 10).

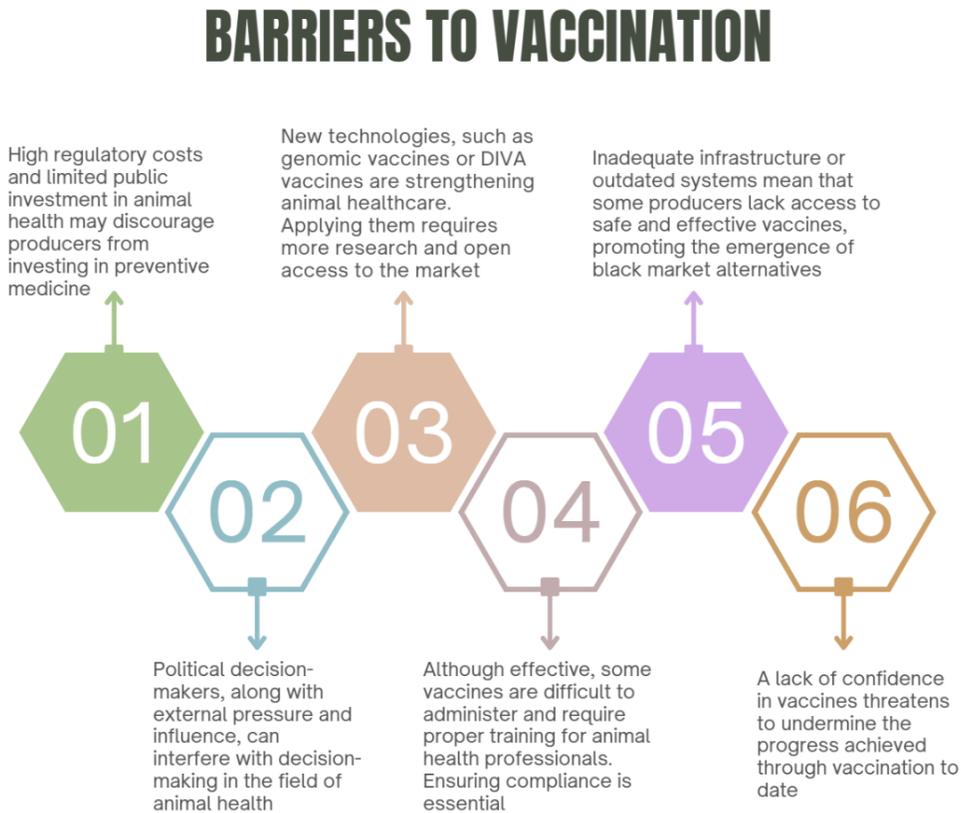


Figure 10 - Barriers to vaccination - source: (Health For Animals, 2021)

## 3. Chapter III – Zoonoses

Zoonotic diseases, or zoonoses, are infectious diseases transmitted by animal vertebrates to humans and transmission occurs at the human-animal-environment interface. These diseases can be transmitted via food, water, vectors, direct contact with animals, or indirectly by fomites or environmental contamination. Zoonoses pose significant risks to both human and animal health and can have profound socio-economic consequences, affecting livelihoods and national economies (FAOUN et al., 2019).

Close interactions among humans, animals, and their shared environments, combined with anthropogenic activities and changes in climate and land use, have altered ecological conditions and significantly influenced the transmission dynamics and geographical distribution of zoonotic pathogens (Mrzljak et al., 2020).

It is estimated that zoonotic diseases account for approximately, in humans, 2.5 billion cases of illness and 2.7 million deaths globally each year (CDC, 2024).

The WHO recently published a list of potential causes of future public health emergencies, all of which are zoonotic in nature, highlighting the critical need to address the animal–human transmission interface (WHO, 2025).

These priority diseases currently include:

- COVID-19
- Crimean-Congo haemorrhagic fever
- Ebola virus disease and Marburg virus disease
- Lassa fever
- Middle East Respiratory Syndrome Coronavirus (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS)
- Nipah and henipaviral diseases
- Rift Valley fever
- Zika
- *Disease X* – a placeholder denoting the potential emergence of an as-yet-unknown pathogen capable of causing a serious international epidemic (WHO, 2025).

The number of recognised zoonotic diseases has increased over the past two decades, and this trend is projected to continue (Mrzljak et al., 2020).

Furthermore, it is estimated that approximately 60% of all human pathogens are of animal origin, with around 75% of emerging infectious diseases in humans originating from animals, most commonly wildlife (Barton Behravesh, 2019; Mrzljak et al., 2020).

Given the substantial impact of both emerging and endemic zoonoses on public health, fostering coordinated collaboration between human and animal health sectors through a multisectoral OH approach is essential for improving health outcomes and ensuring global health security (FAO et al., 2022).

The emergence of zoonotic diseases is a complex and multifactorial process, influenced by a variety of external factors, or 'drivers,' that create conditions for certain pathogens to expand and adapt to new hosts and ecosystems (Winkler et al., 2025).

These drivers are typically ecological, political, economic, and social in nature, and operate at local, national, regional, and global levels. Geographic areas where these drivers converge at high intensity (concentration and prevalence), where the risk of disease emergence is highest, are commonly referred to as zoonotic disease 'hotspots' (National Research Council (US) et al., 2009; Winkler et al., 2025).

The drivers to emergence of new diseases can be broadly categorised into three environmental domains:

1. Human living environments: Factors such as changes in dietary habits, globalised food systems, urbanisation, increasing densities of human and animal populations, closer contact between people, companion animals, and livestock, demographic shifts, increased human mobility, poverty and compromised public health and veterinary infrastructure contribute to the emergence and re-emergence of zoonotic diseases.
2. Food and agriculture systems: Drivers include the scale and density of livestock production, variability in biosecurity standards, expansion of trade in animal products, inappropriate use of veterinary pharmaceuticals and vaccines, and unsustainable farming practices.
3. Natural ecosystems: Human-induced changes, such as deforestation, land-use change, agricultural encroachment, poaching, and the trade in wildlife and bushmeat, disrupt ecological balance. These activities lead to habitat fragmentation, biodiversity loss, and accelerate climate change, all of which increase the risk of zoonotic disease emergence (Addis et al., 2016; Winkler et al., 2025).

Understanding the primary drivers of emerging zoonotic diseases requires a systemic and integrated analysis of interactions across human, animal, and environmental domains - a core principle of the One Health framework (Figure 11).

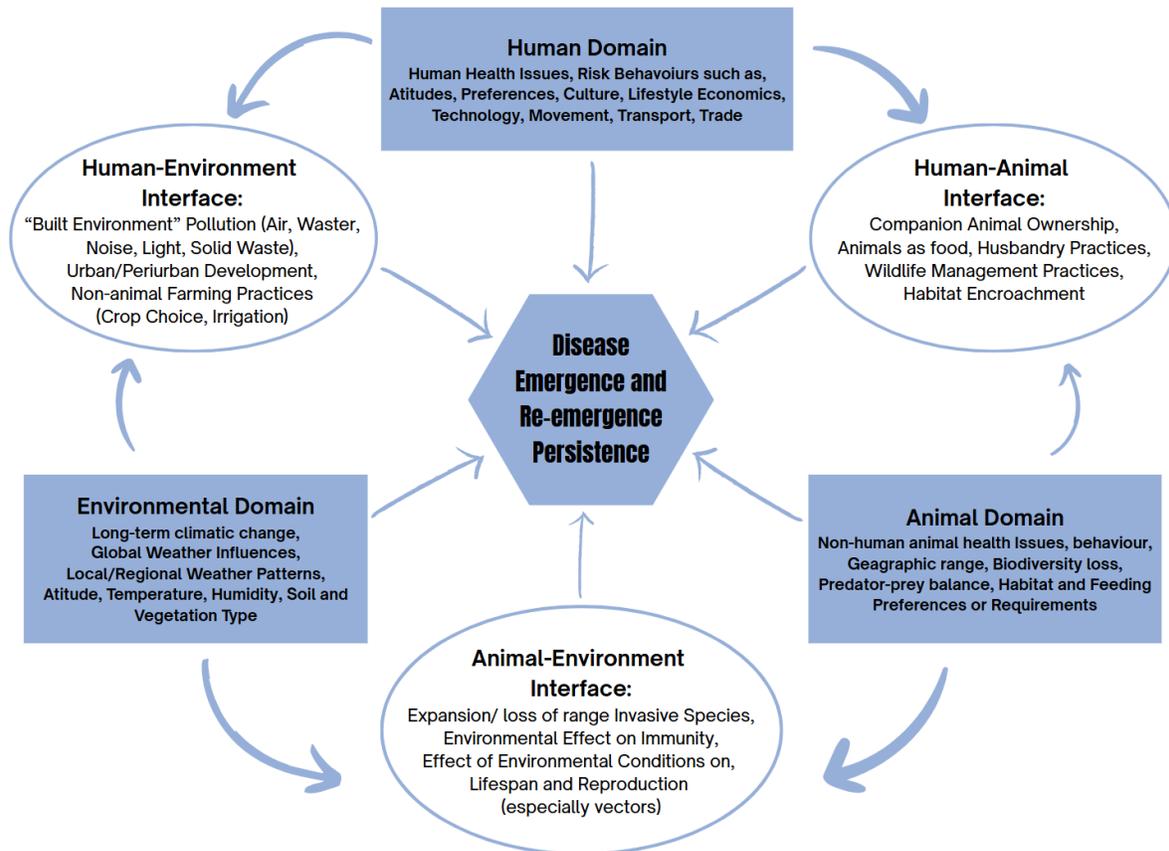


Figure 11 - The interactions across human-animal-environmental domains. Adapted from (Addis et al., 2016)

Although the incidence of emerging infections originating from companion animals remains relatively low, the risk of zoonotic transmission to humans is nonetheless well recognised. This risk is gaining increasing significance due to the growing prevalence of pet ownership in households.

Transmission may occur through direct contact with skin or mucous membranes via bites, scratches, or other interactions, as well as through exposure to animal saliva, urine, and other bodily fluids or secretions (do Vale et al., 2021).

Additional routes of transmission include ingestion of food or water contaminated with animal excreta, inhalation of infectious aerosols or droplets, and vector-borne pathways involving arthropods or other invertebrate carriers (do Vale et al., 2021).

In contrast to the absence of mandatory diagnostic testing and control measures for zoonotic diseases in companion animals, research on infectious diseases in livestock, where testing is both compulsory and routinely conducted, is predominantly directed towards the prevention and control of zoonotic pathogens, particularly those associated with foodborne transmission. (Wu, 2022).

### 3.1. Traineeship-Based Review of Key Zoonoses in Portugal

This chapter provides a brief review of the zoonotic diseases with the highest prevalence recently in Portugal as addressed during the traineeship undertaken at ULS São João, and outlines the role of the veterinary surgeon in the control and prevention of such diseases.

According to the *2023 Zoonoses Report in Europe*, among the zoonoses and zoonotic agents monitored annually, the most frequently reported zoonotic diseases in humans in Portugal were campylobacteriosis (1,057 cases), salmonellosis (535 cases), and listeriosis (99 cases), which are all food- and waterborne infections (EFSA & ECDC, 2024).

The consumption of contaminated food and exposure to unhygienic environments remain significant global public health concerns. Foodborne hazards are defined as adverse events associated with food consumption that may cause illness (Hobbs & Roberts, 2007).

These hazards may be chemical, physical, or biological in nature. Among these, biological hazards, specifically bacterial, viral, or parasitic pathogens, are considered the most frequent and severe, particularly in food of animal origin (Bernardo & Cardo, 2017).

Biological hazards may be introduced at any stage of the food production chain, although the most critical risks are those originating directly from sub clinically infected animals. Pathogenic microorganisms implicated in foodborne diseases are broadly categorised into those causing toxicoinfections and those inducing infectious (extraintestinal) diseases.

Toxicoinfections are typically associated with gastrointestinal symptoms such as diarrhoea, vomiting, and fever, manifesting within 2 to 72 hours following ingestion of contaminated food. These infections result from the proliferation of specific bacteria or the presence of their toxins (Bernardo & Cardo, 2017).

Pathogenic bacteria involved in toxicoinfections may enter food endogenously, through asymptotically infected animal or plant sources, or exogenously during processing or handling. The agents responsible for foodborne toxicoinfections are exclusively bacterial in nature.

In addition to *Salmonella sp.*, *Campylobacter jejuni*, *C. coli*, *C. lari*, *C. upsaliensis*, and *Listeria monocytogenes*, which are responsible for the aforementioned diseases, several other notable examples of bacterial pathogens can be identified.

These include: *Staphylococcus aureus*, *Yersinia enterocolitica*, *Vibrio cholerae*, *V. parahaemolyticus*, *V. vulnificus*, *E. coli* VTEC, ETEC e EPEC, *Clostridium botulinum*, *Cl. perfringens*, *Shigella spp.*, *Bacillus cereus*, *Plesiomonas shigelloides* and *Aeromonas hydrophila* (Bernardo & Cardo, 2017).

Campylobacteriosis remains the most commonly reported foodborne gastrointestinal infection in humans across the EU. The report identified *Campylobacter spp.* in various animal categories, with the highest detection rates observed in broilers, cats, dogs, and cattle, and the highest contamination rates found in meat derived from broilers and turkeys.

Salmonellosis ranked as the second most reported foodborne gastrointestinal infection in the EU. The highest proportion of *Salmonella*-positive samples collected by competent authorities at slaughterhouses, in EU, were recorded in turkeys and broilers.

Listeriosis is a food- and waterborne disease of particular concern within the EU due to its high rates of hospitalisation and mortality (*Listeriosis - Annual Epidemiological Report for 2023*, 2025). The human infection typically occurs through the consumption of contaminated food, mostly meat from bovine animals, and the contamination occurs throughout the all food chain from primary production to manufacturing and distribution stages (EFSA & ECDC, 2024; ECDC, 2012).

Additional microbial agents responsible for infectious (extraintestinal) diseases include: *Brucella spp.*, *Mycobacterium spp.*, *Bacillus anthracis*, *Streptococcus suis*, *Norovirus*, *Astrovirus*, *Adenovirus*, *Calicivirus*, *Rotavirus*, and a range of parasitic organisms (Bernardo & Cardo, 2017).

In Europe, approximately 15% of all foodborne toxicoinfections are attributed to meat products, whereas in Eastern regions, fish products account for nearly 40% of foodborne intoxications (Bernardo & Cardo, 2017).

Veterinary inspection is the set of medical, veterinary and regulatory practices aimed at verifying and certifying that products of animal origin to be placed on the market have been obtained from healthy animals, processed under hygienic conditions that guarantee animal welfare and public health protection.

The concept of “food security” is defined as the right of all individuals to have consistent access to adequate food that meets nutritional and cultural needs. “Access” refers to economic affordability, while “availability” relates to the volume of food produced and distributed. Food security encompasses sustainability and rational resource and management, including the minimisation of waste and prevention of stockpiling (Bernardo & Cardo, 2017).

Veterinary inspectors focus on “availability” (production) and “use” (hygiene and nutritiousness). The hygiene aspects of foodstuffs are modernly referred to as “food safety”.

Food safety is related to the presence of foodborne hazards like chemical, physical, and biological hazards in food at the point of consumption (Selamat & Iqbal, 2016).

In January 2000, the European Commission published the White Paper on Food Safety (COM 719/99), followed by the establishment of the European Food Safety Authority (EFSA) in January 2002. These developments marked significant progress toward a unified European food safety policy.

### 3.2. Traineeship-Based Review of Key Zoonoses in sub-Saharan Africa

This chapter provides a brief review of the zoonotic diseases studied during the traineeship at HIOH, conducted within the framework of the ELIPSA project.

In sub-Saharan Africa, fever is a common symptom among (human) patients seeking healthcare. Key non-malaria causes of severe febrile illness in sub-Saharan Africa include bacterial bloodstream infections, HIV-related coinfections such as cryptococcal disease and disseminated tuberculosis, arboviral infections, and bacterial zoonoses like brucellosis, leptospirosis, Q fever, and rickettsioses (Carugati et al., 2019).

In a study of Ateudjieu et al. (2023), it was found that, in 2023, the three most reported zoonotic diseases in sub-Saharan Africa were MPOX, Rift Valley Fever, and Ebola viral disease. All of these diseases are zoonoses and potentially deadly to human.

The same study identified several common animal reservoirs, including cattle, rodents, pigs, bats, camels, gorillas, poultry, snakes, and cats. These animals frequently interact with humans - whether as food sources, pets, livestock for commercial purposes, or through activities such as hunting and hiking.

Additionally, urbanization and deforestation are driving an increase in human-commensal species like rats, which heightens the risk of zoonotic diseases spreading to humans (Ateudjieu et al., 2023).

During the traineeship, the trainee had the opportunity to review a range of scientific articles and engage with researchers conducting investigations into zoonotic diseases such as Anthrax and MPOX.

Through the ELIPSA project the trainee studied the risk behaviours related to these zoonoses. The primary risk behaviour is associated with direct contact with reservoir animals. This contact may occur through activities such as hunting, handling or consuming wild animals (Moss, 2024), or having contact with contaminated soil, animal products or carcasses of infected animals as stated by Nana et al. (2022), Gruber Kalamas (2004) and Sangwan et al. (2025).

Regarding to MPOX, and because of the global outbreak in 2022, the WHO declared it a public health emergency (Alakunle et al., 2024; Moss, 2024). Anthrax, due to its significant infectivity in animals, it is a WOAHL-listed diseases and must be reported to the WOAHL as indicated in its Terrestrial Animal Health Code (WOAHL, 2025a).

The close interconnectedness between humans, animals, and the environment highlights the need for a OH approach in the study and management of zoonoses. Improved understanding of transmission route and identification of animal reservoirs is essential for preventing future outbreaks (Moss, 2024; Sangwan et al., 2025).

The studies stress the importance of proactive measures, investing more in the prevention of zoonoses rather than focusing primarily on their control after emergence, and this is applicable for any disease (Nana et al., 2022).

Addressing the complex and interconnected challenges of zoonotic diseases requires international collaboration and the implementation of a OH framework (Elisha et al., 2024).

### 3.3. Vector-Borne Diseases

Vector-borne diseases cause more than 700 000 human deaths annually, and they account for more than 17% of all infectious diseases (WHO, 2024).

A vector is a living organism that carries and transmits infectious agents from one animal to another, including humans. Vectors are often arthropods, such as mosquitoes, ticks, fleas, lice, and flies. They can spread disease either actively or passively (*Vector-Borne Diseases* | EFSA, 2023).

Biological vectors, like mosquitoes and ticks, harbour pathogens that can multiply inside them and are typically transmitted through bites. In contrast, mechanical vectors, such as flies, carry pathogens externally and spread them through physical contact (*Vector-Borne Diseases* | EFSA, 2023).

The complex interactions among pathogens, hosts, vectors and environmental factors play a crucial role in this process. Additionally, various factors, such as ecological, environmental, and demographic changes, can drive these adaptations and contribute to the emergence and re-emergence of infectious diseases. These influences often create favourable conditions to new routes of infection, new types of vectors and new pathogens (Chala & Hamde, 2021).

Arthropod vectors, like ticks and mosquitoes, are very sensitive to environmental changes, particularly temperature, due to their ectothermic nature. Rising temperatures can enhance their development, survival, population density, and geographic spread, while also accelerating pathogen replication and disease transmission (Jánová, 2019; Winkler et al., 2025).

These factors contribute to the increasing incidence of vector-borne zoonoses, as observed and predicted by climate models. Additionally, extreme weather events (e.g., floods, storms) and human-driven environmental changes, like deforestation, wetland drainage, and intensive agriculture, alter ecosystems, influencing vector habitats and disease distribution (Jánová, 2019; Winkler et al., 2025).

#### 3.4. The Human-Animal Interface: The Concept of Spillover and Associated Risk Factors

With the increasing ease of global travel and the expansion of trade of animal- and plant-derived products, the transmission of pathogens has become more rapid and geographically widespread. Zoonotic diseases may be either newly emerging or re-emerging (Moss, 2024).

The transmission of pathogens between different species, commonly referred to as the crossing of species barriers, is an ecological phenomenon known as “host jump”, “cross-species transmission”, “zoonotic transfer”, “pathogen spillover”, or “zoonotic spillover” (Ellwanger & Chies, 2021; Plowright et al., 2017).

To be more specific, “spillover” can be described as the “cross-species transmission of a parasite into a host population not previously infected” and usually refers to the cross-species transmission of pathogens from wildlife (vertebrate animals) to humans (Ellwanger & Chies, 2021; Plowright et al., 2017).

Spillover events involving pathogens and the consequent outbreaks of disease in humans, animals, and plants, can occur when multiple drivers of disease emergence and dissemination converge (One Health High-Level Expert et al., 2023).

Anthropogenic global changes are among the principal contributors to both the emergence and propagation of infectious diseases. These same changes also contribute to biodiversity loss and the degradation of ecosystem functions, factors that, in turn, further facilitate the emergence of diseases (One Health High-Level Expert et al., 2023).

By increasing contact between wildlife, livestock, and human populations, disruptions in natural ecosystems, elevate the risk of zoonotic transmission and creates favourable conditions for pandemics to arise (Vétérinaires Sans Frontières, 2025; Winkler et al., 2025).

Risk behaviours related to zoonotic disease transmission vary according to socio-economic and geographic contexts. During the traineeship, several region-specific risk behaviours were studied and investigated.

At ULS São João, it was possible to study behaviours associated with zoonotic disease occurrence within the Portuguese socio-economic context. In the second component of the traineeship, conducted at HIOH, risk behaviours prevalent in sub-Saharan Africa, particularly in Ivory Coast and the Central African Republic, were reviewed and acknowledged.

In Europe, risk behaviours are predominantly occupational, involving veterinary surgeons and individuals working in slaughterhouses, livestock production, or within the animal-based food supply chain (Wu, 2022).

Specific practices include handling carcasses of infected animals - such as their tissues, organs, bodily fluids, or hides as well as, and more widely to the general public, the consumption of animal-derived products, particularly meat from infected animals, unpasteurised milk, and related dairy products (Wu, 2022).

Regarding zoonotic risk behaviours in sub-Saharan Africa, a systematic review was undertaken to inform the development of digital tools for the ELIPSA project. The following table outlines selected risk behaviours identified during this traineeship (Table 1).

Risk Behaviours to zoonotic diseases in Sub-Saharan Africa context		
Spiritual rites and ceremonies:	Some communities consider the meat from the forest to be “protected” by the forest and prefer it to meat from livestock.	(Manyike et al., 2025); (Vétérinaires Sans Frontières)
Close and prolonged contact with animals:	Contact with livestock, livestock markets or butchering animals;	(Traore et al., 2021); (Osoro et al., 2015); (Tialla, 2015); (Steinmann et al., 2006); (Vétérinaires Sans Frontières)
	Ownership of livestock with pastoralist production system, natural breeding and acquisition of new animals into farm;	
	Handle hides, tissues, organs and other viscera without any protection;	
	Contact with raw meat and carcasses of infected animals, infection through cuts and wounds, through splashing of infected blood or other fluid to the conjunctiva;	
	Assisting animals during labour without any protection;	
	Humans and animals sleeping under the same roof;	
Animal meat and other products consumption:	Consumption of unpasteurized milk and other milk products;	(Traore et al., 2021);

	Eating animals found dead, without knowing the cause of their death;	(Steinmann et al., 2006); (Tialla, 2015); (Oliveira et al., 2024); (Vétérinaires Sans Frontières)
Animal-Animal interactions:	Livestock graze at the edge of the forest, where they may come into contact with wild species carrying diseases; Diseases inside the herd;	(Vétérinaires Sans Frontières)
Human-Animal-Environment interactions:	Lack of feed; grazing of livestock by the roadsides and in rubbish dumps; Wildlife trafficking, incorrect use of soil or water, urbanization without sustainability, habitat destruction, lack of basic sanitation, fires and deforestation, absence and/or breaking of health protocols	(Kagira & Kanyari, 2010); (Pettan-Brewer et al., 2021)
Inadequate Veterinary Services:	Provision, availability, cost and care of drugs and vaccines; lack of knowledge;	(Bath et al., 2016); (Kagira & Kanyari, 2010)

Table 1 - Risk Behaviours to zoonotic diseases in Sub-Saharan Africa context

The likelihood of zoonotic spillover from reservoir hosts to humans depends on the alignment and overcoming of several ecological and biological barriers, including host density, pathogen persistence in the environment, human exposure pathways, and host immune responses. This multi-barrier model is elaborated by Plowright et al. (2017).

To effectively identify strategies for the prevention or mitigation of future zoonotic spillover events, a thorough understanding of both pathogen ecology within natural reservoirs and the nature of human–host interactions is essential.

The prevention of pathogen spillover to other animal species is also of critical importance, as successful adaptation to new animal hosts may facilitate future transmission to humans. A well-documented example is the influenza virus, which initially circulates in avian species, subsequently adapts to swine, and can ultimately be transmitted to humans.

Long-term, interdisciplinary research efforts are critical. These should systematically investigate the ecological dynamics of zoonotic pathogens in their wildlife hosts, alongside the risk factors that facilitate spillover, in order to enhance the predictive capacity and preparedness for future pandemics (Cunningham et al., 2017).

From a public health perspective, the earlier changes detected in ecosystems, such as the emergence of vectors or reservoir hosts, or the earlier a pathogen is detected in animals or along the food chain, the more effective the communication and integration between surveillance systems across sectors, the greater the likelihood that spillover to humans can be prevented, contained or both (Winkler et al., 2025).

#### 4. Chapter IV - Antimicrobial Resistance

Another emerging threat for zoonotic outbreaks is the improper use of antimicrobials in humans, animals and the environment, which promotes the development of AMR and can ultimately result in human resistant infections through contact, food chain or other pathways (Ateudjieu et al., 2023).

AMR arises when pathogenic microorganisms, such as bacteria, viruses, fungi, and parasites, develop resistance to the antimicrobial agents intended to eliminate them, rendering these treatments ineffective.

As a result, infections become increasingly difficult, or even impossible, to control and treat, thereby elevating the risk of disease progression, transmission, and potentially leading to fatal outcomes (WHO, 2023).

As mentioned, the inappropriate use, overuse, and underuse of antimicrobials across the human, animal, and environmental sectors are key drivers of AMR, facilitating the local and global dissemination of resistant bacteria and their associated resistance genes.

Additional contributing factors include absent or inadequate immunization, inadequate IPC measures, environmental contamination, and the geographical movement of infected hosts - whether human, animal, or plant - capable of harbouring and transmitting pathogenic agents to other susceptible individuals (McEwen & Collignon, 2018).

#### 4.1. The Rational Use of Antimicrobials in Veterinary Medicine – Antimicrobial Stewardship

AMS in both human and veterinary medicine refers to a set of coordinated strategies aimed at mitigating the public health threat posed by AMR, while safeguarding the continued efficacy of existing antimicrobial agents (*Antimicrobial Use in Veterinary Practice | American Veterinary Medical Association, 2025; Lloyd & Page, 2018*).

The concept of stewardship encompasses responsible and judicious management practices. In light of the escalating prevalence of multi-drug-resistant bacteria across human and veterinary healthcare, as well as in agriculture, there is an urgent need to implement stewardship measures effectively to ensure the sustainable use of antimicrobial drugs (Lloyd & Page, 2018; Winkler et al., 2025)

While governmental organisations have primarily concentrated their AMS efforts on livestock production and the food industry, the development of such equal foot measures for companion animals has largely been led by veterinary professional societies and associations (Lloyd & Page, 2018).

Good stewardship practice (GSP) is characterised by a proactive, adaptable, and continuously improving approach to antimicrobial usage. The objectives, core strategies, and critical success factors identified in human healthcare AMS programmes offer valuable insights and can serve as a foundation for enhancing veterinary AMS frameworks (Lloyd & Page, 2018) (Figure 12).

# ELEMENTS FOR EFFECTIVE VETERINARY ANTIMICROBIAL STEWARDSHIP FRAMEWORK

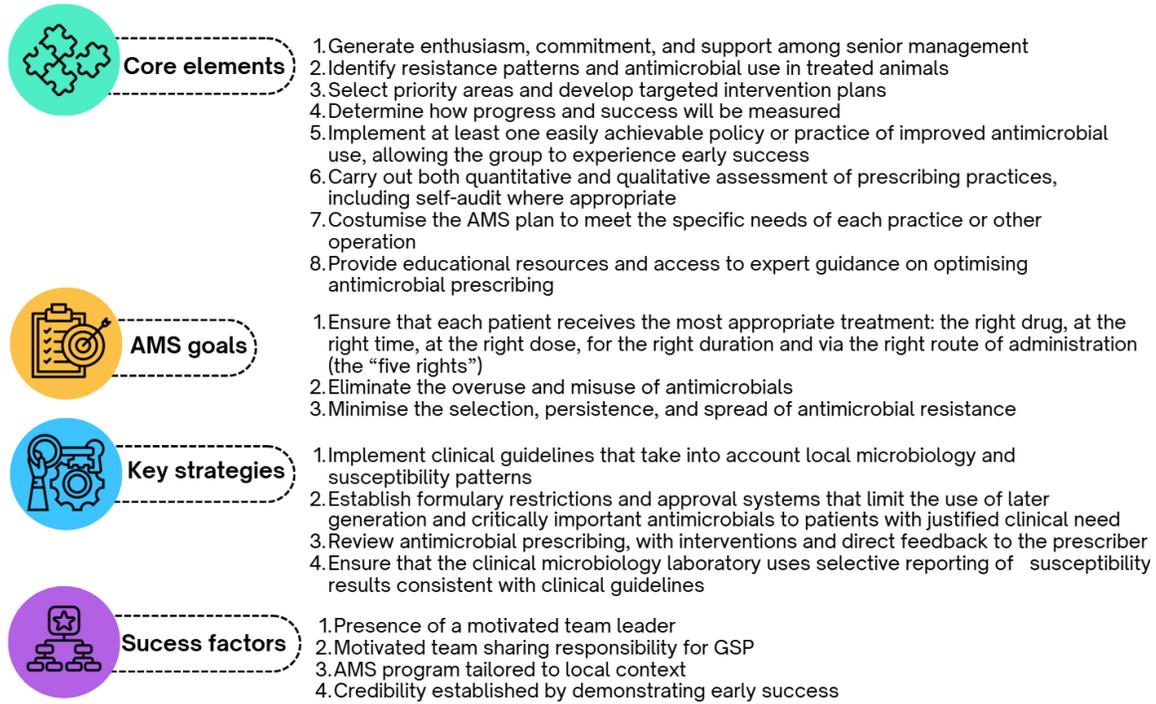


Figure 12 - Elements for effective Veterinary Antimicrobial Stewardship Framework – adapted from: (Lloyd & Page, 2018)

The framework is designed to accommodate the diverse needs of the veterinary profession, which range from the treatment of individual animals to the management of herd and flock health. It is structured around five core elements that define GSP: Responsibility, Reduce, Replace, Refine, and Review (Lloyd & Page, 2018) (Figure 13).



Figure 13 - The five core elements for a GSP – source: (Lloyd & Page, 2018)

Responsibility serves as the fundamental and guiding principle of effective AMS programmes. Such initiatives rely on the active leadership, support, and engagement of senior management (Lloyd & Page, 2018).

Under corporate governance, the GSP framework requires that all uses of antimicrobials be scrutinised through the lenses of reduction, replacement, and refinement (Lloyd & Page, 2018).

GSP promotes the comprehensive exploration of potential reduction strategies. These may include genetic selection for disease resistance, the development and deployment of vaccines, identification of modifiable risk factors, and ongoing measurement and evaluation of current practices (Lloyd & Page, 2018).

A critical factor in reducing AMR, and probably the most important, is the implementation of enhanced IPC measures, commonly referred to as biosecurity.

Biosecurity encompasses a suite of preventative strategies aimed at minimising the risk of introducing, establishing, or spreading infectious diseases within animal populations (Douglas, 2025). Practical examples include the isolation of incoming or symptomatic animals, early disease detection, and the application of vaccination protocols.

Another key factor in AMR is the accurate diagnosis of infections. When microbiological testing is conducted, it significantly facilitates the selection of the most appropriate antimicrobial medication, thereby supporting GSP.

Replacement, another key pillar of GSP, involves the substitution of antimicrobials with non-antimicrobial alternatives whenever appropriate (Lloyd & Page, 2018).

Opportunities for refinement pertain to the optimisation of antimicrobial use, including the development and implementation of tailored therapeutic plans (Figure 14).

# DECISION-MAKING IN SUSPECTED BACTERIAL INFECTION

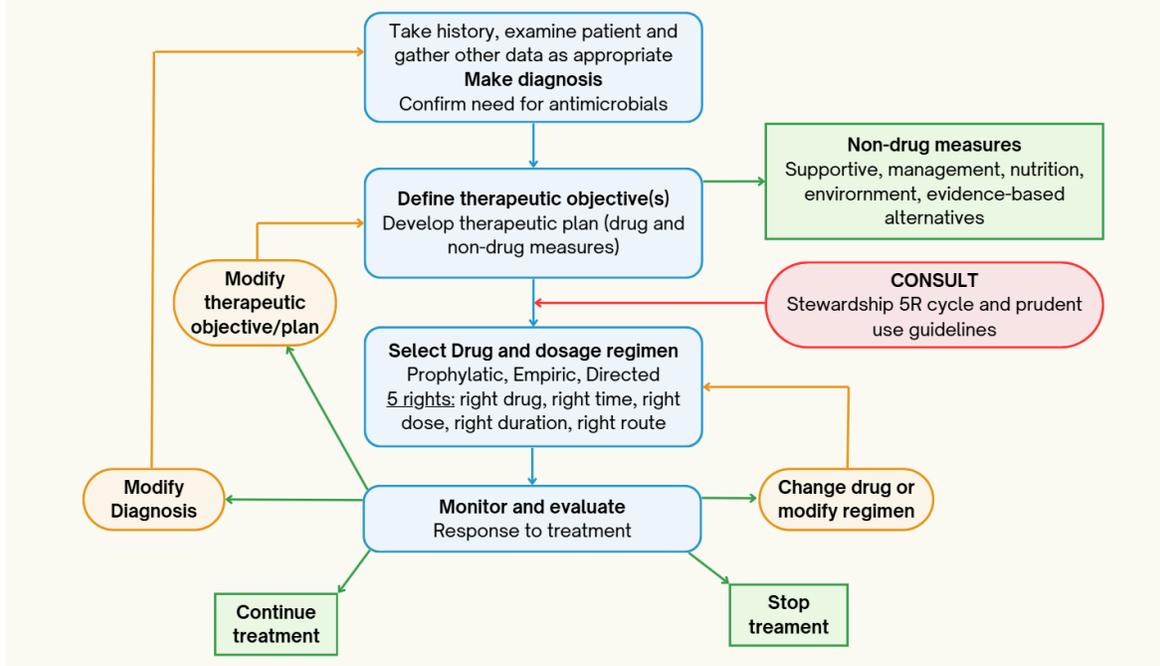


Figure 14 - Decision-Making in suspected bacterial infection - Adapted from: (Lloyd & Page, 2018)

The final element, review, focuses on the systematic assessment of antimicrobial usage, resistance trends, and the resources required. Review remains a cornerstone of AMS by enabling the evaluation of progress against defined objectives and supporting an iterative cycle of continuous improvement. This process is inherently sustainable and contributes to ongoing enhancements in practice quality (Lloyd & Page, 2018).

AMS is essential for preserving the effectiveness of antimicrobial agents and addressing the global threat of resistance. The GSP framework offers a structured, adaptable approach tailored to the diverse needs of veterinary medicine. Centred on the principles of Responsibility, Reduce, Replace, Refine, and Review, GSP promotes evidence-based, preventive, and continuously improving practices.

Through enhanced biosecurity, alternative treatments, and optimised antimicrobial use, veterinary professionals can contribute significantly to global AMS efforts. Education, sustained commitment, leadership, and cross-sector collaboration will be key to ensuring responsible antimicrobial use and protecting both animal and public health for the future (FDA Centre for Veterinary Medicine, 2023; Lloyd & Page, 2018).

## 5. Chapter V – A Veterinary Medicine Traineeship in a Human Health Tertiary-care Hospital

### 5.1. Observational Placement within the Infectious Disease Department: Insights into Multidisciplinary Clinical Practice

Clinical duties within the IDD involved, among other responsibilities, the daily monitoring and discussion of patient cases in the inpatient wards, including those in the Infectious Diseases Intensive Care Unit.

During the traineeship, eight cases of zoonotic diseases were observed and followed in hospitalised patients (Figure 15).

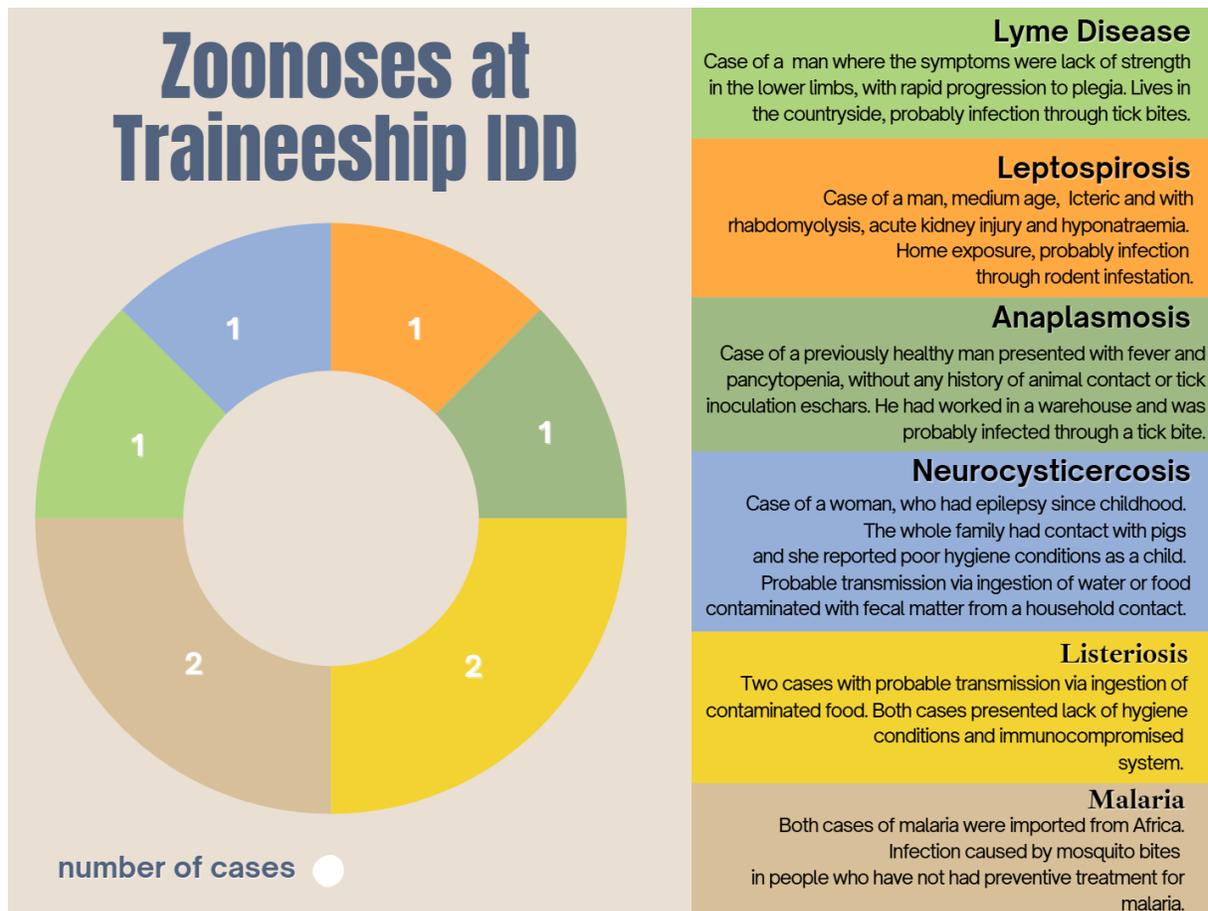


Figure 15 - Zoonoses at traineeship at IDD ward

Through the observation of the zoonotic cases, a comprehensive understanding and critical thinking approach was developed regarding the significant influence of the epidemiological context on the clinical presentation and progression of infectious diseases. From a public health perspective, the identification, reporting, and communication of zoonotic cases, particularly from the animal health sector, are considered crucial. Preventive and control measures are required to disrupt transmission chains and, where feasible, to work towards the eradication of such diseases.

Weekly departmental meetings were attended, where case-based discussions and presentations of research conducted by medical specialists and residents were held. During weekly clinical meetings with IDD physicians, several topics of high relevance from a zoonotic and public health perspective were presented. These discussions reinforced the interconnectedness of human and animal health, especially in the context of IPC and emerging infectious diseases.

#### *5.1.1. Zoonosis as Emerging Infectious Diseases*

Within the activities promoted by the Emerging Infectious Diseases Unit, integrated in the IDD and dedicated to institutional preparedness and clinical response to patients with emerging and re-emerging infections, particularly high-consequence emerging infections, it was possible to participate in training sessions on the use of personal protective equipment (PPE) for professionals from both the IDD and Emergency Department.

In addition, it was possible to attend Epidemiological Bulletin presentations designed to keep the IDD team up to date on the current epidemiology of emerging diseases. One of these sessions, highlighted major zoonotic threats, including Lassa fever, Crimean-Congo haemorrhagic fever, avian influenza, MERS-CoV, anaplasmosis, and chikungunya virus infection.

These examples illustrate the growing importance of zoonotic disease surveillance, early detection, and preparedness, and highlight the role of veterinary professionals within the OH framework.

### 5.1.2. Infection Control and Prevention

#### 5.1.2.a - Hand Hygiene: A Shared Clinical Standard

A refresher session was held focusing on best practices in hand hygiene, including protocols for antiseptic hand rubbing, handwashing, and the ‘Five Moments for Hand Hygiene’ as outlined by the WHO. Emphasis was placed on the critical importance of completing each step thoroughly, as lapses in technique can compromise patient safety (WHO, 2009).

While these procedures were demonstrated in a human healthcare context, they are equally valid and *ipsis verbis* applicable to veterinary practice. The knowledge and habits formed during this traineeship are directly transferable to daily veterinary care.

Hand hygiene, in particular, is a fundamental competency that underpins safe patient interactions in both fields (and learned during veterinary medicine studies). This shared premise reinforces the principle that effective IPC protocols is universal across all healthcare disciplines.

IC aims to minimize the spread of pathogens by interrupting their access to the source, mode of transmission and host, in both human and animal health settings.

Key measures include hand hygiene, disinfection, water sanitation, proper handling of sharps and biological materials, vaccination, isolation, personal PPE, regular cleaning of surfaces and equipment, and training and education of both clinic staff and patients/owners (Sørensen, 2021; Willemsen et al., 2019).

IPC is one of the most effective and cost-saving interventions available, and the global IPC report showed that hand hygiene and environmental hygiene in healthcare facilities could more than halve the risk of deaths due to infections with AMR pathogens (WHO et al., 2023).

In contrast to the progress made in human healthcare, IPC in veterinary practice is often inconsistently applied. There is frequently a lack of structured IPC protocols, dedicated IPC personnel, and ongoing monitoring. This gap presents a significant risk to both animals and humans, particularly given the zoonotic nature of many infectious agents and the growing threat of AMR (Willemsen et al., 2019).

Hand hygiene should be practiced both after tasks that could contaminate the hands and before any activity where pathogens might be transferred to surfaces, people, or animals. People tend to remember to wash their hands only when they appear “dirty”. However, it's important to note that harmful pathogens are often present even when hands look clean. Veterinary staff working in environments like barns, where dirty hands are often considered “normal” not always do this (Anderson, 2015).

Thoroughly handwashing is a fundamental component of good hygiene and serves as the primary defence against infection. Hands are easily contaminated with pathogens, posing a risk not only of self-infection but also of transmitting infections to colleagues and patients through direct contact or shared surfaces. Staff-related transmission is widely recognized as the most common route of disease spread. This concern applies equally to animal healthcare environment (Tambuwal et al., 2009).

Veterinary professionals must be aware of the proper hand washing techniques, including washing with water and soap or by friction with alcohol-based antiseptic solution ABAS (DGS, 2019).

Additionally, to hand hygiene techniques, the veterinary surgeon or any animal healthcare staff, should remove jewellery and watches and keep nails short and clean as they can carry bacteria. Check hands for cuts or abrasions and cover with a waterproof dressing. A break in the skin is a portal for pathogens to enter in the body (Phillips, 2020).

The routine/social hand wash is the one which is more frequently performed. This is the hand wash to perform, always, between (non-infectious) patients. It takes approximately 15–30 seconds, using either soap and water or alcohol-based rub. (Phillips, 2020) (Figure 16 and Figure 17).

# Handwashing

Duration of the handwash 15-20 seconds  
 Duration of the entire procedure 40-60 seconds



1 Wet hands with water;



2 Apply enough soap to cover all hand surfaces;



3 Rub hands palm to palm;



4 Right palm over left dorsum with interlaced fingers and vice-versa;



5 Palm to palm with fingers interlaced;



6 Back of fingers to opposing palms with fingers interlocked;



7 Rotational rubbing of left thumb clasped in right palm and vice-versa;



8 Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice-versa;



9 Rinse hands with water;



10 Dry hands thoroughly with a single use towel;



11 Use towel to turn off faucet;



12 Your hands are now safe.

Figure 16 - Hand Washing

# Handrubbing

Duration of the entire procedure 20-30 seconds



1a Apply a palmful of the product in a cupped hand, covering all surfaces;



2 Rub hands palm to palm;



4 Right palm over left dorsum with interlaced fingers and vice-versa;



5 Palm to palm with fingers interlaced;



6 Back of fingers to opposing palms with fingers interlocked;



7 Rotational rubbing of left thumb clasped in right palm and vice-versa;



8 Rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice-versa;



9 Once dry, your hands are safe.

Figure 17 - Hand Rubbing

Effective hand hygiene is critical in preventing the transmission of pathogens in both human and veterinary healthcare settings. The WHO's 'Five Moments for Hand Hygiene' have been adapted to the veterinary context and correspond to five key points of contact with patients or their environment. Each moment is essential to maintaining a safe clinical environment:

- Before touching a patient or its immediate surroundings (cage, etc.). This includes, among others, check temperature, feeding, and placing non-invasive equipment.
- Before performing a clean or aseptic procedure, wash hands immediately before placing or caring for IV or urinary catheters, injections, endotracheal intubation, feeding tube placement, drain management, etc.
- After any bodily fluid exposure such as cleaning up urine, faeces, vomit, etc., or handling blood or other biological samples.
- After touching a patient even if gloves were worn to prevent the spread of microorganisms within the clinical environment.
- After touching a patient's surroundings for example, leaving the ward surgery or treatment areas, even if you did not touch a patient, as these surfaces may still be contaminated (Phillips, 2020).

The Figure 18 shows the five critical moments for hand hygiene during patient interaction.

Nosocomial and zoonotic infections represent persistent and inherent risks within veterinary hospital environments. This underscores the critical need for the implementation of proactive IPC policies aimed at reducing the incidence of sporadic cases and preventing potential outbreaks.

Among the various preventive strategies, personal hygiene, particularly hand hygiene, remains a cornerstone in limiting the transmission of infectious agents.

Lessons from human medicine, along with the steady emergence of new infectious diseases, suggest that IPC will face growing challenges in the future. Consequently, it is imperative that IPC protocols are routinely evaluated and updated to reflect the latest research findings and accumulated clinical experience (Weese, 2004).

# YOUR 5 MOMENTS FOR HAND HYGIENE



SAVE LIVES CLEAN YOUR HANDS



1	BEFORE TOUCHING A PATIENT	WHEN?	Clean your hands before touching a patient when approaching the animal.
		WHY?	To protect the patient/animal against harmful germs carried on your hands.
2	BEFORE CLEAN/ASEPTIC PROCEDURE	WHEN?	Clean your hands immediately before performing a clean/aseptic procedure.
		WHY?	To protect the patient against harmful germs, including the patient's own, from entering his body.
3	AFTER BODY FLUID EXPOSURE RISK	WHEN?	Clean your hands immediately after an exposure risk to body fluids (and after glove removal).
		WHY?	To protect yourself and the health-care environment from harmful patient germs.
4	AFTER TOUCHING A PATIENT	WHEN?	Clean your hands after touching a patient and her/his immediate surroundings, when leaving the patient's side.
		WHY?	To protect yourself and the health-care environment from harmful patient germs.
5	AFTER TOUCHING PATIENT SURROUNDINGS	WHEN?	Clean your hands after touching any object or furniture in the patient's immediate surroundings, when leaving – even if the patient has not been touched.
		WHY?	To protect yourself and the health-care environment from harmful patient germs.

Figure 18 - Your Five Moments for Hand Hygiene. Adapted from: 5 Moments for Hand Hygiene, WHO, 2009

## 5.1.2.b - Importance of Disinfection in Healthcare Settings

In healthcare, the major risk of any procedure is the risk of infection. Because of this, to ensure that any materials, instruments or surfaces do not transmit infectious pathogens to patients/animals, is mandatory to achieve a correct disinfection and sterilization. As such, thorough and effective cleaning, disinfection, and sterilisation protocols are essential in preventing the transmission of these agents. These measures must be guided by clear institutional policies (Rutala et al., 2023).

According to Tyski et al. (2022), the development of infections caused by microorganisms can be significantly reduced through the appropriate and targeted use of effective antiseptics and disinfectants. These chemical agents are fundamental to control and prevent nosocomial infections and are widely used for both topical applications and hard surface disinfection in healthcare settings.

Antiseptics and disinfectants contain biocidal agents, active chemical substances with antimicrobial properties, which may be used singly or in combination depending on the target microorganisms and context of use (McDonnell & Russell, 1999).

The efficacy of biocidal products is influenced by several factors, including the chemical formulation, organic load present on the surface, synergistic effects of active compounds, temperature and dilution of the product and the test method used to evaluate antimicrobial activity (Tyski et al., 2022).

Users must be familiar with the spectrum of biocidal activity, which should be assessed according to appropriate standards. These standards define specific test methods to evaluate whether a disinfectant or antiseptic exhibits bactericidal, sporicidal, mycobactericidal/tuberculocidal, fungicidal/yeasticidal or virucidal activity (Tyski et al., 2022).

When selecting a disinfectant, several critical factors must be considered, including the concentration of the active agent, type, quantity, and location of microorganisms and the environmental conditions (e.g. surface type or presence of organic material) (Sandle, 2019).

The term “Biocide” refers to any broad-spectrum chemical agent capable of inactivating microorganisms. The suffixes “-static” and “cidal” describe the nature of activity, where “static” refers to agents which inhibit microbial growth (e.g., bacteriostatic, sporistatic) and “cidal”, refers to agents which kill the target organism (e.g., sporicidal, virucidal) (McDonnell & Russell, 1999).

In contrast, sterilisation is defined as a physical or chemical process that completely eliminates or destroys all forms of microbial life, including spores (McDonnell & Russell, 1999).

In Europe, disinfectants are regulated by the European Chemicals Agency (ECHA) to ensure they meet established safety and efficacy standards before they are made available for public use (ECHA, 2013).

According to ECHA and Environmental Protection Agency (US EPA, 2015), careful reading of product labels is the most important step for the correct and effective application of disinfectants.

The “Directions for Use” section provides critical information, including appropriate settings for use, target microorganisms, correct application method and the required contact time for efficacy.

Contact time refers to the period during which the disinfectant must remain on the surface to exert its full antimicrobial effect. It encompasses the time required for the agent to bind to the microorganism, penetrate the cell wall, and act at the intended intracellular target site (Sandle, 2019).

An example of targeted biocidal activity includes the use of phenol, which has demonstrated bactericidal efficacy against *Bacillus anthracis* (Sandle, 2019).

An illustration is provided below showing an example of a disinfectant label, along with guidance on how to interpret label components for appropriate and safe use in clinical settings (Figure 19).

# HOW TO READ A DISINFECTANT LABEL

READ THE ENTIRE LABEL

**The label is the law!**

NOTE: BELOW IS AN EXAMPLE OF INFORMATION THAT CAN BE FOUND ON A DISINFECTANT LABEL

## STORAGE & DISPOSAL:

How should the disinfectant be stored? How Should I dispose of expired disinfectant? What should I do with the container?

## ACTIVE INGREDIENTS:

What are the disinfecting chemicals presents?

## DISINFECTANT FOR DIRECT CONTACT SURFACES

### Active ingredients:

didecyldimethylammonium chloride.....4.5%  
glutaraldehyde.....5%  
excipients.....100%

### WARNINGS AND RECOMMENDATIONS FOR THE PURE PRODUCT:

In order to avoid risks to people and the environment, follow the instructions for use. It must be disposed of correctly, avoiding drop into the environment. It causes severe skin burns and serious eye damage. Harmful if swallowed. It causes skin irritation. It may cause allergy or asthma symptoms or breathing difficulties if inhaled. It may cause an allergic skin reaction. Harmful if inhaled. It may irritate the respiratory tract. Very toxic to aquatic life with long lasting harmful effects. Do not breathe vapours. Wear protective goggles and a mask. Wear gloves.  
**IF SWALLOWED:** Rinse mouth. Do not induce vomiting.  
**IF CONTACT WITH EYES:** Rinse with water for several minutes. Remove contact lenses.  
**IF CONTACT WITH SKIN:** Remove contaminated clothing. Rinse skin with water.  
**IF INHALED:** If breathing is difficult, move the victim outdoors and keep him/her at rest in a comfortable position for breathing. In case of irritation or rash: Consult a doctor.

### If you feel unwell contact:

CAV - POISON CENTER TELEPHONE: 800250250

activity	application dose	time
Bactericidal	1% (100 ml in 10 l)	5 min
Fungicidal	1% (100 ml in 10 l)	15 min
Virucidal	1% (100 ml in 10 l)	15 min

## PRECAUTIONARY STATEMENTS:

How do I use this disinfectant safely? Do I need PPE?

## DIRECTIONS FOR USE

(Instructions for use):  
Where should the disinfectant be used? What type of surfaces can the disinfectant be used on? How do I properly use the disinfectant?

**Authorised applications and uses**  
Disinfection of surfaces, materials, equipment and furniture that do not come into direct contact with foodstuffs or animal feed.

### INSTRUCTIONS FOR USE:

Disinfection must be carried out using the doses and contact time established in the Indicative table, the highest dose in the table according to the biocidal activity required. Restricted to professional use. It must be carried out using the application techniques of a double bucket, mop or aseptic cloth, etc. Apply in the absence of personnel. It is recommended not to enter the premises until 3 hours have passed after applying the product in the solution used. Although LIMOSEPTIC SF has detergent properties, it is recommended to clean the premises before using the product. It does not need to be rinsed. It is recommended to dispose of the solution used after each use. Do not mix with any other product. Ventilate adequately before entering. Warning: contains Glutaraldehyde.

## FIRST AID:

What should I do if I get the disinfectant in my eyes or mouth, on my skin, or if I breath it in?

## SIGNAL WORDS

(caution, warning, danger):  
How risky is this disinfectant if it is swallowed, inhaled, or absorbed through the skin?



## CONTACT TIME:

How long does the surface have to stay wet with the disinfectant to kill germs? What kind of germs does the disinfectant kill?

Figure 19 - How to proper use disinfectant – adapted from: “How to read a disinfectant label”, from EPA

### 5.1.2.c – Transmission-Based Precaution Measures and Patient Isolation

The importance of implementing transmission-based precautions, tailored to the specific route of infection, was strongly emphasised, during this traineeship. These measures are critical to interrupting the chain of infection and should be consistently applied across healthcare settings.

Depending on the nature of the infection, measures of precaution may be classified as either standard/basic precautions, applied universally to all patients, or transmission-based precautions, which are tailored to the specific infectious agent and its route of transmission.

The primary categories include:

- Contact isolation: Designed to prevent transmission through direct or indirect contact with infected patients or contaminated surfaces within their environment.
- Droplet isolation: Aim to limit the spread of pathogens transmitted via respiratory droplets generated through talking, coughing, or sneezing, or through contact between mucous membranes and respiratory secretions.
- Particle isolation: Implemented to prevent the transmission of infectious agents via aerosolised particles capable of remaining suspended in the air over long distances due to their small size.

Each patient's unit should be clearly marked with signage indicating the specific type of transmission-based precaution required, corresponding to the infectious agent's mode of transmission.

In all cases, patients should ideally be placed in single-occupancy rooms. If isolation in individual rooms is not feasible, cohorting patients infected or colonised with the same pathogen is recommended (Bastos, 2023).

Once again, this traineeship, underpinned by a OH perspective, reinforces the principle that many healthcare practices are universally applicable across species. Just as in human medicine, the use of PPE is also key in animal health settings.

In veterinary contexts, PPE functions as a barrier against disease transmission and spread, but is only effective if: the correct pieces of equipment are selected, based on exposure hazard and context, taking into account the zoonotic risk and the biosecurity risk; each piece of equipment should remain intact the whole procedure; PPE should be properly fitted and worn; no mistakes should occur during patient examination and the steps of donning, doffing, cleaning and disinfection should be followed correctly (Christmann, 2020).

Consistent with Christmann's findings (2020), avoiding zoonotic disease spread is always the priority on animal health settings. The mode of transmission, how exposure would most likely occur during patient examination, and the ulterior environmental contamination, should also be considered.

To illustrate this, PPE protocols in intensive livestock production systems categorise protection into four levels (A–D).

The level D consists of a basic work uniform to protect against nuisance contamination. The level C is used when the concentration and types of airborne substances are known and the criteria for using air purifying respirators are met. The level B is used when the highest level of respiratory protection is necessary, but a lesser level of skin protection is needed than Level A. The level A is when the greatest protection for skin, respiratory and eye is required.

PPE includes respiratory protection, eye and face protection, gloves, protective clothing, protective footwear, and head and hearing protection (FAD PReP/NAHEMS, 2011).

In intensive production settings, the layout of work zones further enhances the efficiency and safety of PPE usage.

The hot zone where the infected animals are housed, is contaminated and only personnel wearing appropriate PPE can enter. The warm zone is where employees perform final decontamination, disinfection and doffing in the decontamination corridor of this zone. The cold zone is the work area with a lower risk of exposure. Here, employees can enter without PPE and don their equipment here.

Each zone should be clearly delineated, equipped with hand hygiene stations, waste disposal facilities, and visible signage guiding workflow direction (Christmann, 2020).

Another example of an appropriate animal health measure for the prevention and control of infectious diseases is the provision of designated isolation areas in hospitals and similar healthcare settings, for animals suspected of being infected. In veterinary hospitals, the establishment of such isolation facilities is mandatory in order to prevent the transmission of infectious agents to other animals. If a hospital is not adequately equipped to manage cases requiring isolation, it should transfer both suspected and confirmed infectious animals to a facility where appropriate containment and care can be ensured.

These examples underscore how IPC principles in animal healthcare, including the correct use of PPE, transmission-based precautions, well established infectious zones, rigorous hand hygiene, and effective disinfection, mirror those employed in human medicine. These shared strategies further validate the OH approach to infectious disease prevention and control.

## 5.2. Following the Traveller's Appointment

Traveller's medicine is defined as a clinical consultation during which, based on the traveller's destination(s) and individual profile, comprehensive advice and information are conveyed.

This includes the provision of guidance regarding preventive strategies to be implemented before, during, and after travel, as well as the administration of context and region-specific vaccinations. These appointments are conducted by specialists in infectious diseases, and are highly individualised, with recommendations tailored to the specific circumstances and health profile of each traveller.

Each travel itinerary is rigorously assessed, including the destination(s), duration of stay, intended activities, mode of transport, and traveller characteristics.

During the traineeship, three such consultations were observed. A OH approach was employed to explore preventive measures for avoiding the acquisition of infectious diseases, particularly those transmitted via contaminated food, direct contact with animals, or vectors.

Appropriate vaccination schedules for various destinations and traveller profile were also reviewed and discussed.

Vaccinations commonly recommended, depending on the epidemiological profile of the intended destination, included: Hepatitis A, Typhoid Fever, Yellow Fever, Poliomyelitis, and Japanese Encephalitis.

The growing volume of global travel and trade, particularly travel to remote or resource-limited regions for purposes such as adventure tourism, necessitates careful consideration. These destinations often lack reliable access to freshwater and robust food safety regulations and may involve close contact with wildlife. As such, these factors significantly influence traveller's consultations, requiring comprehensive and personalised advice and tailored recommendations to mitigate potential health risks.

As outlined earlier in the chapter titled "Traineeship-Based Review of Key Zoonoses in Portugal", the consumption of contaminated food and exposure to unhygienic environments remain significant global public health concerns (Hobbs & Roberts, 2007).

That being said, several recommendations and preventive measures were given to the travellers to minimise the risk of food and waterborne infections (Table 2).

During the traveller's appointment the risk of zoonotic diseases transmitted through direct animal contact was also addressed. Conditions such as skin infections caused by *Pasteurella multocida*, or severe neurological diseases such as rabies, were discussed.

*Pasteurella multocida* is a bacterial agent commonly found in the upper respiratory tract of healthy domestic animals, including pets, livestock, and wild species. It is associated with various acute and chronic animal diseases (Piorunek et al., 2023).

Human infections typically result from bites, scratches, or contact with animal saliva. Approximately 50% of dog bite wounds and 75% of cat bite wounds are reported to harbour this pathogenic agent. Rare cases have been reported following bites from exotic and wild animals (Piorunek et al., 2023).

Rabies, transmitted primarily through saliva, is considered one of the oldest and most fatal zoonoses, with a global distribution. It poses a major public health concern in over 150 countries (Kumar et al., 2023).

While wildlife represents the primary reservoir in developed countries, domestic dogs are responsible for 99% of human cases in endemic regions, with over 95% of fatalities occurring in Africa and Asia. (WOAH, 2025b).

Man is considered a dead-end of the infection. The incubation period in rabid dogs varies from 10 days to 6 months. While in humans it ranges from days to years, with an average of 2-3 months (Kumar et al., 2023).

Human infection can be prevented in 99% of cases with prompt administration of rabies vaccine and specific immunoglobulins. Prophylactic strategies include pre-exposure prophylaxis (PrEP) for high-risk individuals (e.g., veterinarians, travellers to endemic areas), and post-exposure prophylaxis (PEP), which involves wound cleaning, immunoglobulin administration, and vaccination (Liu & Cahill, 2020).

Rabies is 100% preventable with vaccination of domestic dogs, which remains the principal vector of transmission in many regions (WOAH, 2025b).

Several preventive measures are mandatory to prevent scratches from animals, in the traveller's consultation were shared to minimise the risk of infections (Table 2).

Another major concern for travellers is the vector-borne infectious diseases. Vector-borne diseases constitute over 17% of all infectious diseases globally and are responsible for more than 700,000 human deaths annually (WHO, 2024).

The emergence of vector-borne diseases is closely linked to ecological and environmental factors, including human encroachment, climate change, and increased mobility (Chala & Hamde, 2021).

Several major vector-borne diseases were discussed during the consultations, including malaria, which remains a critical concern globally.

While insecticides and antimalarial drugs have been effective, increasing resistance among mosquito populations threatens current control strategies (Schinkel et al., 2024).

Prevention of Zika virus infection in pregnant women was particularly emphasised, given the risk of congenital abnormalities.

Below there is a table with the most important recommendations for an adult traveller, from a OH point of view (adapted from the ULS São João Recommendations for travellers).

Hazards	Associated zoonotic diseases	Pathogens	Prevention
Food and waterborne hazards	Foodborne toxicoinfections	<i>Salmonella sp.</i> , <i>Staphylococcus aureus</i> , <i>Yersinia enterocolitica</i> , <i>Vibrio cholerae</i> , <i>E. coli VTEC</i> , <i>ETEC e EPEC</i> , <i>Clostridium botulinum</i> , <i>Campylobacter jejuni</i> , <i>Shigella spp.</i> , <i>Listeria monocytogenes</i> , <i>Bacillus cereus</i> and others	Only consume bottled water; tap water only if boiled for 3 minutes; do not consume ice. Food: avoid uncooked food (salads, vegetables, unpasteurized milk, cheeses, avoid shellfish...), eat food that has been cooked, even if only for a short time; wash fruit with bottled water and peel it; brush your teeth with bottled water.
Vector-borne diseases transmitted by mosquitoes, ticks, lice	Malaria, Zika, Japanese encephalitis, Dengue, etc.	Plasmodium falciparum, plasmodium vivax, Dengue Virus, Zika virus, Japanese encephalitis virus	Prefer light clothing and choose clothing that covers the skin as much as possible. Consistent use of insect repellent; mosquito net with insecticide on the bed and windows; permethrin spray to protect clothes.
Scratches and bites from other animals	Skin infectious and other infections	<i>Staphylococcus spp.</i> , <i>Streptococcus pyogenes</i> ; genera <i>Lyssavirus</i> , rabies virus	Avoid contact with animals, especially in the wild. If bitten, wash the wound immediately and thoroughly with soap and water; apply betadine; go to the health service within 72 hours for rabies vaccine and immunoglobulin.

Table 2 - Travel-related hazards and preventive measures

In response to the growing number of travels undertaken with companion animals to remote and resource-limited regions, often involving close contact with wildlife and posing risks to both the owner and the animal, a pet-specific adaptation of the travel consultation model has been developed (CDC, 2025).

This initiative led to the creation of a “Guide to Travelling with Your Pet”, offering comprehensive recommendations regarding necessary vaccinations, documentation, and preventive strategies for safe companion animals travelling internationally. The methodology and development process of this guide are described in detail in Part III.

### 5.3. Shadowing Clinical Consultations on immunomodulation and infection risk, and the antibiotherapy appointment

Several factors significantly influence the transmission and distribution of zoonotic diseases, including the close interconnection between humans, animals, and the environment and human activity.

The incidence of zoonotic diseases continues to rise, with immunocompromised individuals facing an inherently elevated risk of infection and adverse outcomes.

This increased vulnerability is associated with atypical clinical presentations, potential delays in diagnostic testing (e.g., serological assays), a higher likelihood of disseminated or advanced disease, and the need for extended treatment and recovery periods (Mrzljak et al., 2020). Immunocompromised patients are particularly susceptible not only to common zoonotic pathogens but also to rarer and emerging agents (Jelocnik et al., 2025).

A notable study conducted in Spain by Garcia-Sanchez et al. (2024), evaluated colonisation and/or infection by zoonotic agents in immunocompromised patients under the age of 20 who owned dogs and/or cats, thereby assessing the zoonotic transmission potential associated with companion animals.

Living with a life-threatening condition that necessitates prolonged therapy can have a profound psychological impact; in this context, interactions with pets might offer meaningful mental health benefits.

The study concluded that, given the preventable nature of most zoonotic diseases, the psychosocial advantages of pet ownership for these patients outweigh the potential health risks, provided that core veterinary preventive measures are observed.

These findings underscore the vital importance of implementing a multidisciplinary OH approach in the care of patients, particularly those presumed to be immunocompromised due to underlying disease. This approach not only acknowledges the therapeutic value of human-animal interactions but also emphasises the need to identify and mitigate any potential risks associated with such contact.

Only through this balanced and integrated perspective can the health and well-being of all, humans, animals, and the broader environment, be effectively promoted and preserved (Mrzljak et al., 2020).

#### *5.3.1. Appointment for immunomodulation and infection risk assessment*

The appointment for immunomodulation and infection risk assessment appointment serves to monitor patients with immune-mediated inflammatory conditions undergoing treatment with immunomodulatory and immunosuppressive therapies. During these consultations, patients are systematically screened for infectious diseases in their active, latent and past forms, and suspected diagnoses are further investigated, with treatment and preventive strategies implemented where appropriate, including vaccination.

This service has been operational at the IDD since 2009, offering dedicated support to clinicians managing patients with immune-mediated diseases (News, 2023).

#### *5.3.2. Appointment for antibiotherapy*

The antibiotic therapy appointments cater to complex cases involving multidrug-resistant hospital-acquired pathogens.

These pathogens are typically isolated from patients who have undergone prolonged antibiotic exposure and are often severely debilitated and, sometimes, immunocompromised. This cohort includes patients with vascular or osteoarticular prostheses infections, as well as those with extended hospital stays or long-term therapeutic regimens.

Both of these clinical services, appointment for immunomodulation and infection risk assessment and appointment for antibiotherapy, are of particular relevance within the OH framework - from identifying behaviours that increase the risk of zoonotic infections to addressing AMR, respectively. As such, they represent valuable learning opportunities during this placement as a veterinary medicine student.

#### 5.4. Overview of Activities Observed in the Unit for Infection Prevention, Control and Antimicrobial Resistance During the Traineeship

The UPCIRA team comprises a multidisciplinary group of professionals including nurses, physicians, pharmacists, epidemiologists and engineers, who work together to monitor data on infectious risk agents and antimicrobial usage, detect and respond to outbreaks, implement IPC measures and support the different department areas on AMS.

It is important to clarify that the UPCIRA (UL-PPCIRA of ULS-São João) does not constitute a clinical department, such as IDD, nor is it directly affiliated with any clinical service. Rather, it functions within the hospital's Epidemiology Department and operates transversally across various clinical departments.

It serves an advisory role, supporting clinical governance in decision-making processes related to infection control and AMS.

Broadly, the UPCIRA undertakes two principal domains of activity: AMS and IPC.

The AMS component includes routine monitoring of specific departments through the *Antimicrobial Prescription Support Programme (Programa de apoio à prescrição de antimicrobianos - PAPA)*, which is implemented in units such as Haematology, Neurosurgery, Orthopaedics, General Surgery, Cardiothoracic Surgery, Plastic Surgery, Vascular Surgery, Urology, the Burns Unit, and the Renal Transplant Unit.

The unit is also responsible for the *authorisation of restricted-use antimicrobials* and engages in *ad hoc* tasks such as *evaluating the quantity and quality of antimicrobial prescriptions, addressing prescription-related issues, and developing clinical protocols.*

The IPC activities encompass initiatives to *promote compliance with hand hygiene practices* (through targeted training and auditing), *surveillance and containment of epidemiologically significant microorganisms* (e.g., carbapenemase-producing organisms, for which regular screening and cohorting are conducted), as well as *monitoring and isolation of other relevant MDROs or Clostridioides difficile*.

Additional responsibilities include *implementing measures to reduce nosocomial infections - such as the STOP infection programme - and undertaking outbreak investigations, issuing guidance on structural infection control measures* (e.g., hospital cleanliness, sterilisation protocols, and intra-hospital workflows) (Figure 20).

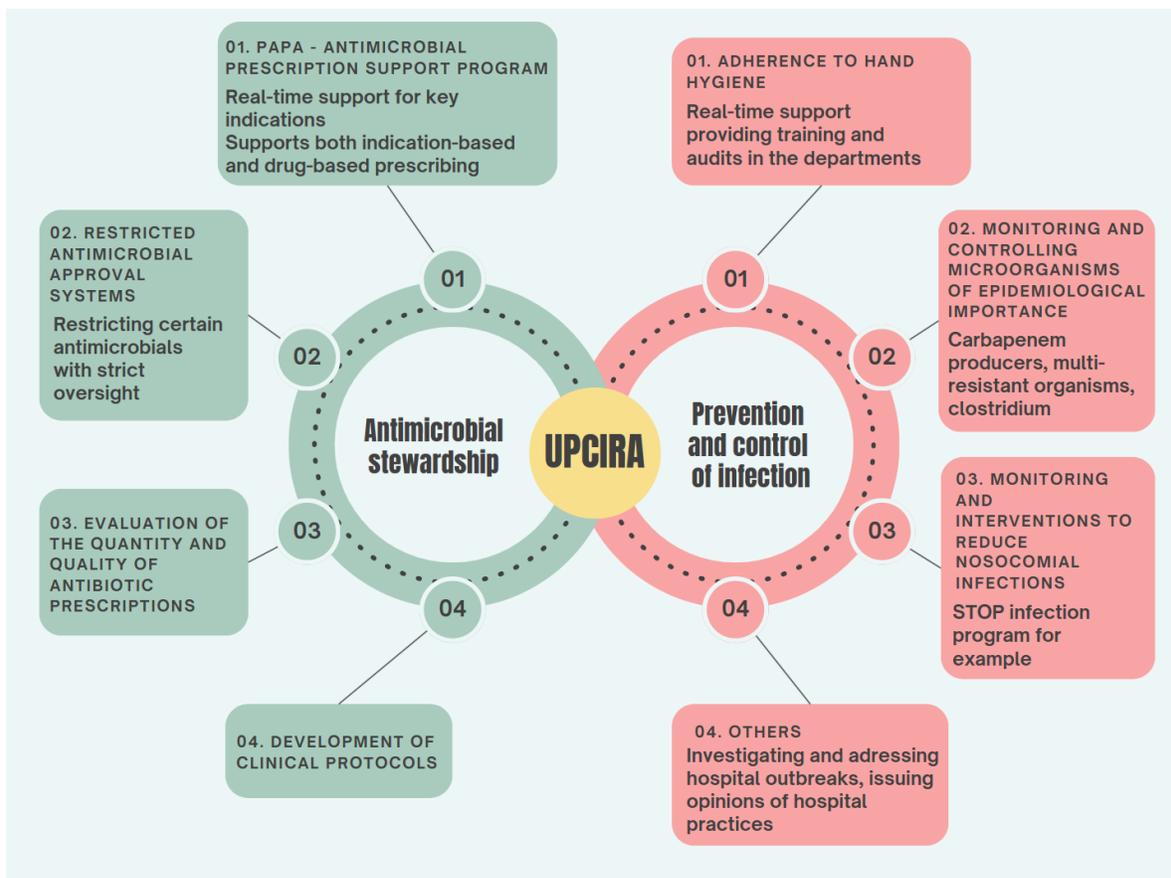


Figure 20 - UPCIRA workflow

#### 5.4.1. Antimicrobial Stewardship at UPCIRA

1.PAPA – *antimicrobial prescription support program* – The objective of PAPA is to optimise antimicrobial therapy by minimising inappropriate prescriptions, unnecessary treatment durations, and avoidable ecological impacts associated with antibiotic use.

This initiative employs both restrictive and facilitative strategies with an educational and behavioural foundation. It incorporates regular feedback on prescription metrics and key indicators, stratified by healthcare unit, clinical service, and individual prescriber - typically disseminated during weekly service-specific meetings.

Prescribing decisions are guided by multiple factors, including local microbial ecology, resistance patterns (antibiograms), the clinical context of the infection (site and origin), and the patient’s medical history. Collectively, these considerations facilitate more rational and targeted antimicrobial prescribing.

2.Restricted antimicrobial approval systems – The *Restricted Platform* is an electronic prescribing system where clinicians submit requests for the use of restricted antimicrobials.

Each request must be accompanied by a detailed clinical justification, demonstrating the necessity of the selected agent for the patient’s infection. These requests are evaluated and validated by the UPCIRA team within a maximum of 72 hours.

The platform applies exclusively to last-line or critical antimicrobials, including quinolones, carbapenems, ceftolozane/tazobactam, ceftazidime/avibactam, colistin, vancomycin, linezolid, daptomycin, and newly introduced agents.

Beyond its role in promoting safer, more appropriate and validated prescribing, the platform also serves as a stewardship tool to monitor and control the use of high-priority antibiotics, thereby supporting resistance mitigation efforts.

3. Evaluation of quantity and quality of antibiotic prescriptions - A robust epidemiological surveillance framework enables the collection of data on local antimicrobial usage and resistance patterns, thereby informing institutional antibiotic stewardship policies.

A key aim of this initiative is the development of tools to monitor the use of critical reserve antibiotics in the context of hospital-acquired infections. By calculating standardised prescribing rates and indicators, institutions can better characterise and quantify antibiotic use.

This initiative is supported by *EU4Health* and aligns with global efforts to address the increasing threat of antimicrobial resistance.

4. Development of clinical protocols - An essential component of antimicrobial stewardship involves the formulation and implementation of evidence-based clinical protocols.

These protocols support clinicians in making informed therapeutic decisions and ensure consistency in prescribing practices across services, in accordance with current microbiological data and best practice guidelines.

#### *5.4.2. Control and Prevention of Infection*

01. Promotion of Hand Hygiene Compliance - Adherence to hand hygiene protocols continues to be regarded as a fundamental component of infection prevention. Ongoing training, auditing, and compliance monitoring have been implemented to ensure that healthcare professionals meet institutional and international standards for hand hygiene in clinical settings, as previously outlined in detail.

02. Surveillance and Management of Microorganisms of Epidemiological Importance - The surveillance programme has been designed to monitor and control microorganisms of epidemiological significance, including carbapenemase-producing *Enterobacterales* (CPE), MDROs, and *Clostridioides difficile*. Particular attention has been given to the identification and cohort isolation of patients colonised or infected with CPE.

During the traineeship, the IPC activities undertaken by the nursing staff were observed, with specific focus on the management of CPE-positive patients and the application of epidemiological surveillance protocols.

According to a 2013 report from CDC, carbapenem-resistant *Enterobacteriaceae* (CRE) were classified among the top three most urgent AMR threats due to their global dissemination, high levels of multidrug resistance, and significant association with mortality, particularly in cases of bloodstream infection.

CPE produce enzymes that hydrolyse carbapenems. These enzymes are frequently encoded on mobile genetic elements such as plasmids, enabling horizontal gene transfer both within *Enterobacteriaceae* and across other bacterial species (Potter et al., 2016).

The clinical threat posed by CPE remains substantial. Carbapenems have long been considered the treatment of choice for infections caused by extended-spectrum  $\beta$ -lactamase-producing *Enterobacteriaceae* (ESBL-E) and other serious Gram-negative bacterial infections (Kyung & Yoo, 2024; van Duin & Doi, 2017).

However, since the initial identification of carbapenemase-producing *Klebsiella pneumoniae*, resistance has disseminated globally, with a growing diversity of resistance mechanisms (Kyung & Yoo, 2024).

Through this surveillance programme, CPE-positive cases are tracked, infection sources are identified, and cohorting and isolation procedures are implemented. These measures are essential for interrupting transmission and containing the spread of antimicrobial-resistant organisms.

03 – Surveillance and Intervention to Reduce Healthcare-Associated Infections – The STOP Infection Programme (Surveillance and Targeted Organisational Prevention) was launched approximately one year ago, with the objective of reducing the incidence of HAIs caused by MDROs. It enables real-time data collection to support integrated epidemiological surveillance in areas as surgical site infections, central line-associated bloodstream infections, ventilator-associated pneumonia infections, catheter-associated urinary tract infections.

04 – Additional Responsibilities: Outbreak Investigation and Institutional Infection Control - Further activities undertaken include the investigation of nosocomial outbreaks, the provision of technical guidance and recommendations regarding institutional infection

control practices, and consultation on structural aspects of healthcare environments (e.g., sanitation, sterilisation, and logistical pathways).

From a OH perspective, the implementation of IPC measures, along with AMS activities at ULS São João, contributes significantly not only to human health but also to animal and environmental health.

When antibiotics in human medicine are managed appropriately, the environmental impact of pharmaceutical residues is reduced, leading to a decrease in the dissemination of resistant organisms/genetic material into ecosystems. These microorganisms may then contaminate natural environments, animal food chains, and ultimately re-enter the human population through zoonotic transmission or the food supply (Winkler et al., 2025).

The global threat of CRE cannot be confined to human populations, as both dissemination and clinical infection caused by CPEs have been reported across species and regions. Although the use of carbapenems is prohibited in livestock in most regions, CRE have been increasingly isolated from various animal species, which act as reservoirs and potential vectors for transmission (Potter et al., 2016)).

A growing body of evidence points to the zoonotic potential of CRE, particularly in companion animals, raising concerns in public health (veterinary and human site).

In light of this, the importance of a coordinated, cross-sectoral approach is paramount. A OH strategy should be adopted - integrating human, veterinary, and environmental health - to raise awareness, prevent cross-sectoral transmission, and contain the global spread of resistance. Surveillance of CRE in humans, animals, and the environment is vital to identifying reservoirs of resistance genes (Potter et al., 2016).

In addition, efforts must be directed towards the rational use of antimicrobials, the development of novel therapeutic agents, and the implementation of dedicated management systems for companion animals, which represent a high-risk group in terms of resistance transmission (Kyung & Yoo, 2024).

The work of the UPCIRA team was closely observed, and its critical role in public health, viewed through a OH lens, was recognised. Consideration was given to how these procedures could be adapted and applied in veterinary contexts, with particular attention to the feasibility of implementing the STOP programme in veterinary settings.

Given that AMR sometimes originates from animal health, particularly through the use of antibiotics in livestock, the expansion of IPC and AMS practices into veterinary settings is likely to yield substantial benefits.

Following the traineeship experience and reflection on its relevance to veterinary practice, a practical contribution was made through the creation of two educational informative posters. These infographics were developed to assist veterinary professionals in clinical settings by outlining key principles for effective IPC strategies, and appropriate antimicrobial prescribing practices in both companion animal and livestock contexts.

The development and rationale of these materials will be presented in Part III.

### 5.5. Participation in a One Health Educational Project: The 'From Hospital to School' Initiative

In the first decade of the 21st century, in the context of the threat of an avian flu pandemic, the emphasis shifted toward training and capacity building in the OH approach, rather than relying solely on disease control and reactive emergency responses. The COVID-19 pandemic came underscore and highlight the critical importance of promoting and integrating this OH concept and approach across all sectors of society.

Although OH may initially appear to be the exclusive domain of professionals in the fields of human, animal, and environmental health, it aspires to be a collaborative and community-oriented vision for health. It seeks to empower individuals across all sectors to act as agents of change in addressing global health challenges (Winkler et al., 2025).

Despite this inclusive vision, several barriers to the implementation of the OH approach still remain. One of the most prominent is the general lack of awareness and understanding of the concept itself. To address this, early and widespread education on OH principles,

tailored to diverse audiences, can foster greater engagement and interdisciplinary collaboration (Pearce et al., 2024 ; Winkler et al., 2025).

In this sense, education for ‘One Health’ has progressively evolved to include school-age children and young people, as has been advocated by the One Health Commission, through sessions specifically dedicated to these age groups, with an informative and participatory/proactive approach (One Health Commission, 2024).

The role of these interventions in increasing young people's knowledge, changing attitudes and practices has not yet been systematically studied, although it is already better known in higher education students (Franco-Martínez et al., 2020).

In Portugal, awareness for OH concept remains limited among health professionals. Implementing OH training initiatives in schools could not only enrich students’ *curricula* but especially enlarge knowledge, awareness and promote transdisciplinary collaboration, thereby enhancing strategies to tackle emerging zoonotic diseases, AMR among others concerns.

This intervention project, named EDUSHE, aims to introduce and embed the OH concept within Portuguese school communities. The objective is to integrate OH into the daily practices of both educators and students, fostering critical thinking, interdisciplinary learning, and the dissemination of the OH approach across a broader society.

The project is led initially by OH professionals, whose role is to catalyse a sustainable process of knowledge transfer and behavioural change within school environments. It is implemented across all levels of education, from preschool to secondary education.

Through sustained capacity-building efforts targeting school staff, the project seeks to enable educational institutions to independently deliver OH education.

The intended outcomes for teachers and school professionals include the ability to understand the OH concept, incorporate it across various subjects, and apply it to real-world school contexts.

Students are expected to gain foundational knowledge of the interconnections between human, animal, and environmental health, understand the implications of zoonoses, AMR, and climate change, and apply these insights in their daily lives while promoting awareness within their communities.

Educational activities are tailored by age group, where preschool and primary students engage with storytelling and interactive sessions to foster empathy, disease prevention awareness, and respect for animals and the environment (Figure 21).



Figure 21 - Raise-awareness session, at ULS São João - source: ULS São João

Secondary students participate in outbreak simulations, helping them understand interdisciplinary responses to emerging diseases and develop communication and prevention strategies based on OH principles.

During the length of the traineeship, six awareness-raising sessions were conducted: one with a secondary school class, four with primary school classes and one in Paediatrics ward at ULS São João. Additionally, training was delivered to school professionals, reinforcing the foundational principles and pedagogical strategies of the OH approach.

In conclusion, education remains a fundamental right and a powerful tool at all stages of life. The transversal nature of the OH concept strongly supports its integration into early educational *curricula*. Based on the experiences and outcomes observed during this traineeship, it can be stated that informed individuals contribute to a more resilient and health-literate society.

## 6. Chapter VI – A Veterinary Medicine Traineeship in a One Health Research Setting

### 6.1. One Health Surveillance and the Transdisciplinary Work

OHS operationalises the OH approach by systematically collecting and integrating data to inform coordinated actions across the human, animal, and environmental health sectors (Berezowski et al., 2019).

The OH approach is a scientific and multidisciplinary strategy that aims to improve the health and well-being of humans and animals within the context of a balanced and sustainable environment (Pettan-Brewer et al., 2021).

As a result, the approach has catalysed the development of enduring and collaborative partnerships across sectors, regions, and continents, recognising the intrinsic interdependence across sectors, with the shared objective of achieving optimal health for humans, animals, plants, and the environment, outcomes that are unlikely to be realised if these sectors operate in isolation (Grajeda, 2021; Pettan-Brewer et al., 2021).

This integrative and holistic framework has brought together a wide array of professionals, including veterinary surgeons, physicians, public health practitioners, environmental scientists, anthropologists, educators, and others, working in close collaboration with communities to address complex health challenges (Pettan-Brewer et al., 2021).

OHS involves the systematic collection, validation, analysis, interpretation, and sharing of information related to humans, animals, and the environment. This integrated model provides an efficient and cost-effective means of estimating disease burden, identifying high-risk populations, and understanding the spatial and temporal patterns of diseases, insights that are essential for guiding health interventions (Grajeda, 2021; Winkler et al., 2025).

There is growing recognition of the need for enhanced collaboration between health sectors to mitigate the adverse impacts of zoonotic diseases. However, education and training within these sectors often remain siloed, confined to discipline-specific *curricula* (Promoting the science of One Health, 2023; Wilkes et al., 2019).

Health facility-based surveillance tend to under detect disease signs in both humans and animals, leading to a systematic underestimation of the actual zoonotic disease burden (Promoting the science of One Health, 2023).

Moreover, most disease notification systems remain segregated by species, human and animal, and rely predominantly on passive reporting mechanisms, which are prone to underreporting. Even notifiable zoonotic diseases have different and isolated, human and animal, report mechanisms. Active surveillance can enhance these efforts, and selecting between approaches should be guided by surveillance objectives and available resources (Promoting the science of One Health, 2023).

Addressing research questions within the OH domain frequently necessitates the integration of methodologies and tools from multiple scientific disciplines. As the field continues to evolve, the adoption of more structured research frameworks may enhance the rigour, consistency, and impact of OH studies (Promoting the science of One Health, 2023).

#### *6.1.1. Cohort Study supporting the development of a One Health Surveillance System*

Cohort studies play a key role in epidemiological research design. The term *cohort*, derived from the Latin *cohors* and originally meaning “a group of soldiers”, is used in research, to describe a type of nonexperimental or observational study. Setia (2016), also commonly referred to as “prospective studies” or “longitudinal studies”

There are some parameters that a cohort study in epidemiology considers (Figure 22).

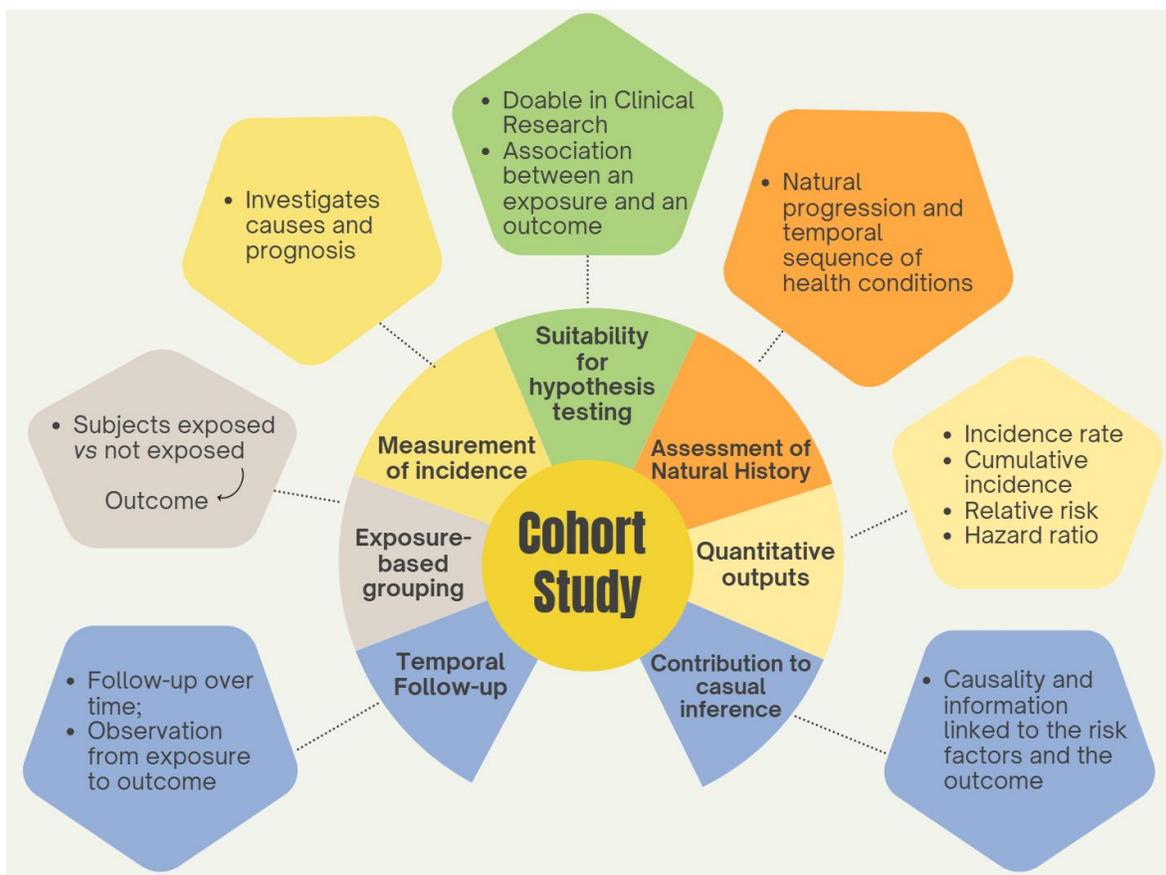


Figure 22 - Cohort study parameters

### 6.1.2. Community-Based Surveillance: A Practical Application of Participatory Approach in a One Health Surveillance System

Community-based surveillance constitutes a critical component of early warning systems, involving the systematic detection and reporting of public health events by individuals within the community (Clara et al., 2020).

Conducting household surveillance at timely intervals enables the early detection of most disease events, making it particularly effective for situations that require rapid response or precise estimation of disease burden. Additionally, applying a OH approach can enhance the cost-effectiveness of household surveillance for zoonotic infections (Grajeda, 2021).

Community health workers play an essential role in the early identification of public health threats, especially in regions with limited access to formal healthcare services. By engaging with communities and linking individuals to services, they strengthen the detection and reporting of priority diseases and events, thereby forming the cornerstone of community-based surveillance (Clara et al., 2020).

Evidence from the implementation of community-based surveillance has demonstrated that strong community engagement, combined with innovative communication strategies, significantly enhances the identification and reporting of health signals.

The design of a participatory study, based on greater collaboration and communication, contributes to a sense of ownership on the communities involved in the study, leading to a greater capacity for trust, acceptance and involvement by the local community. A notable example of a community-based surveillance system is the ELIPSA project, which will be discussed in more detail later (Dias, 2024).

Embedding community-based surveillance within existing surveillance platforms strengthens the foundational capacity of public health systems and promotes a more inclusive and responsive surveillance architecture (Clara et al., 2020 ; Winkler et al., 2025).

## 6.2. Developing a One Health Surveillance System

OH is an integrated multisectoral approach focused on managing global and transnational health threats, by sustainably balancing and improving the health of humans, animals, and ecosystems (Kimani et al., 2019; One Health High-Level Expert et al., 2023).

A substantial proportion of emerging infectious diseases are believed to circulate between animal and human populations prior to their clinical recognition (Aarestrup et al., 2021). Notably, the primary drivers of disease emergence are anthropogenic in nature, arising from human activity, and so too must be the solutions (One Health High-Level Expert et al., 2023).

While numerous surveys routinely collect data on livestock, relatively few explicitly capture information across the broader value chain, limiting the capacity to understand and manage systemic risk (World Bank, 2012).

Therefore, a future catch-all infrastructure should go beyond surveillance of human clinical cases and include standardized sampling that captures the human, animal, and environmental microbiomes over time and across different geographic regions (Aarestrup et al., 2021).

To make this approach possible, governmental funding and/or heavy investment from large international funding organisations must help for research and detection of zoonotic diseases (Aarestrup et al., 2021).

Furthermore, this investment should support the transition from pathogen-specific monitoring to more agnostic, metagenomic surveillance approaches that enable the detection of multiple high-priority pathogens simultaneously (Aarestrup et al., 2021).

Conventional disease surveillance has typically operated within isolated sectors, human, animal and environmental health. In contrast, OHS advocates for an integrated model that simultaneously monitors known and emerging pathogens as well as the underlying ecological and socio-economic drivers of disease emergence. This holistic strategy is essential for preventing and mitigating zoonotic spillover events (One Health High-Level Expert et al., 2023; Winkler et al., 2025).

An example of this integrated model is the ELIPSA project, which follows the OH strategy and will be explained in detail in the next chapter.

The following six steps have been proposed to guide the development of OHS systems (One Health High-Level Expert et al., 2023) (Figure 23).

## STEPS TO ONE HEALTH SURVEILLANCE SYSTEM DEVELOPMENT

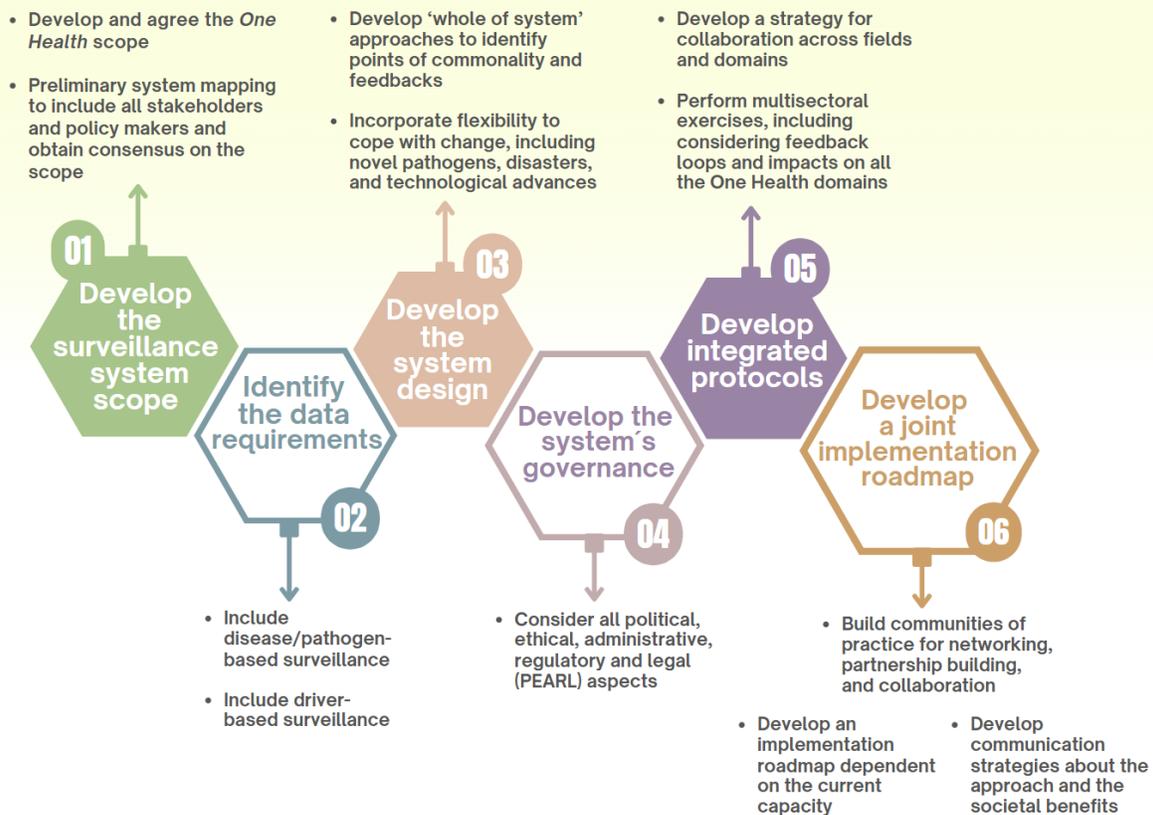


Figure 23 - Steps to One Health Surveillance System Development – adapted from: (One Health High-Level Expert et al., 2023)

Establishing an OHSS begins with building consensus among stakeholders on a shared vision, aligned with the Quadripartite’s One Health definition. System mapping (e.g., causal loop diagrams) helps identify key components, actors, and indicators (One Health High-Level Expert et al., 2023).

The second step involves defining data needs, assessing existing data sources, and integrating both disease and disease driver data, especially ecological and socio-economic factors, to support risk prediction and prevention (One Health High-Level Expert et al., 2023).

Next is the design of an integrated system using a whole-systems approach that can adapt to emerging threats and leverage new technologies like AI, genome sequencing, and citizen-led surveillance (One Health High-Level Expert et al., 2023).

A robust governance framework is essential to address PEARL (political, ethical, administrative, regulatory, legal) challenges. Cross-sectoral coordination and legal support for data sharing and sustainable financing are crucial.

Effective surveillance relies on timely, high-quality data from well-equipped laboratories, and global equity in laboratory capacity, biosafety, and outbreak response is essential. Integration across human, animal, plant, and environmental health sectors, supported by sustainable funding and contingency planning, is vital (One Health High-Level Expert et al., 2023).

The fifth step focuses on integrated reporting protocols and cross-disciplinary collaboration, including simulation exercises for outbreak preparedness (One Health High-Level Expert et al., 2023).

Finally, a joint implementation roadmap is developed, tailored to regional capacities. Effective communication, led by both social and natural scientists, and feedback to communities is vital for long-term success and data-sharing across all levels. (One Health High-Level Expert et al., 2023).

### 6.3. The Establishment of Epidemic Panels for One Health Surveillance in Sub-Saharan Africa (ELIPSA) Project: Contributions from a Veterinary Medicine Traineeship

#### 6.3.1. *A Participatory Approach for the Establishment of a One Health (Community-based) Cohort Study in Sub-Saharan Africa*

Given the widespread distribution of animal reservoirs linked to zoonotic diseases in sub-Saharan Africa, the establishment of comprehensive epidemiological surveillance systems is critical for effective monitoring and response preparedness (Ateudjieu et al., 2023).

The emergence of high-impact zoonotic and potentially zoonotic diseases, such as Ebola and COVID-19, alongside the persistent burden of endemic infections like rabies, highlights the urgent need to reinforce health systems in the region (Ateudjiu et al., 2023).

Sub-Saharan Africa faces emerging threats from infectious diseases every day. Since the Taï National Park in Ivory Coast is a hotspot for the emergence of diseases, the aim is to set up a OH cut-off study there (Dias, 2024).

To be able to carry out this OH approach with communities, it is necessary to involve different stakeholders (Figure 24).

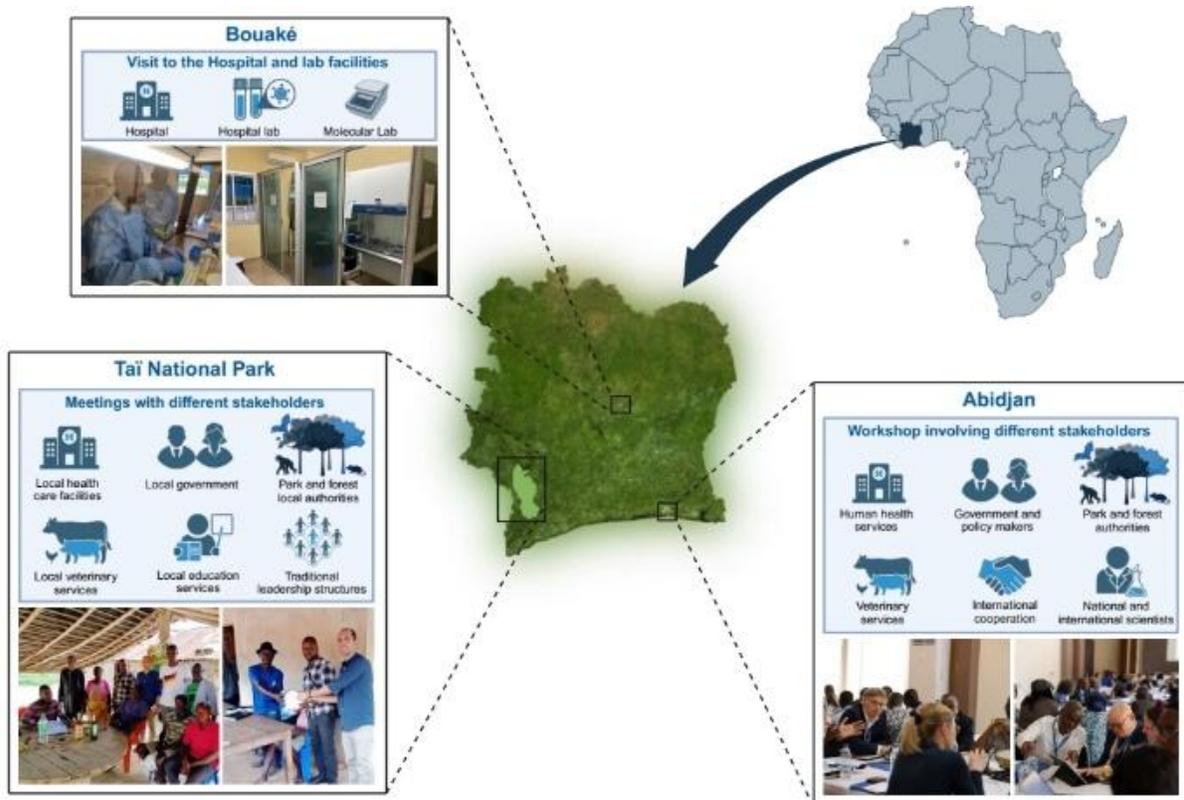


Figure 24 - Participatory approach involving stakeholders at different levels. Source: HIOH

Meetings were organised in nine different communities in order to present the idea of the project to the traditional leadership structures and local authorities. With this, information, opinions, concerns, suggestions were collected, and more was learned about cultural and social norms and beliefs, myths, information gaps and rumours.

This cohort study will be part of a long-term sustainable OHS system, with the aim of providing broader knowledge about the determinants of infectious diseases, particularly zoonotic diseases, their early detection and support for epidemic management (Dias, 2024).

6.3.2. *Establishing an Epidemic Panel Integrating the Human-Animal-Environment Interface for Assessing Infectious Pathogens in Sub-Saharan Africa – The ELIPSA Project*

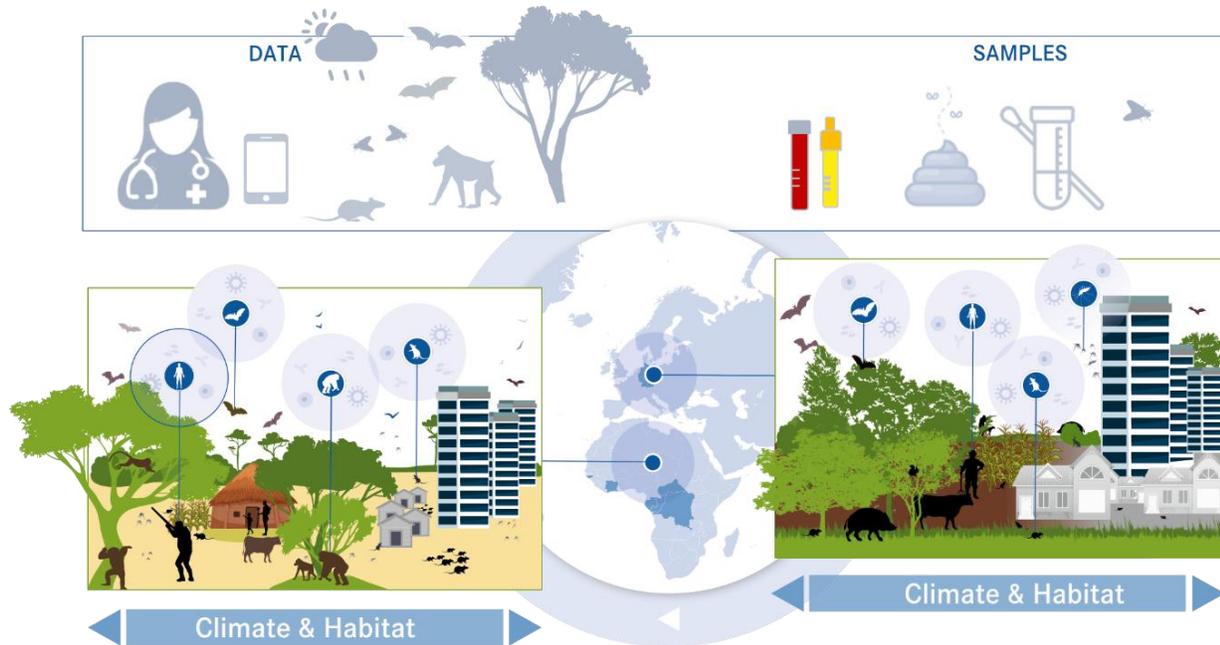


Figure 25 - The ELIPSA project – source: HIOH

The ELIPSA Project is a cohort study designed to establish an epidemic panel grounded in an integrated OH framework in Ivory Coast and the Central African Republic (Figure 25).

Epidemic panels are longitudinal, population-based cohort studies that enable rapid and continuous estimation of key epidemiological parameters essential for the management and surveillance of infectious disease outbreaks within a given population.

This approach facilitates adaptive and timely data collection concerning pathogen burden and transmission frequency, thereby supporting real-time public health decision-making. The methodology is based on a longitudinal sampling strategy, targeting populations in specific geographic areas, with the aim of generating predictive insights into pathogen dynamics and associated risk factors.

Currently, no epidemic panels exist in Ivory Coast or the Central African Republic. Such infrastructures remain scarce across both African and European contexts, despite the continued public health burden posed by infectious diseases.

The ELIPSA project provides an extraordinary and innovative opportunity to integrate environmental, animal, and human health data, enabling a comprehensive assessment of infectious disease impacts across the three domains of the OH triad.

With the collaboration of regional partners and the involvement of 2,000 individuals from the pilot region of interest, the study will implement a multi-stage sampling process, encompassing human participants, their domestic animals, wildlife and the surrounding environment.

This includes on-site health examinations, standardised questionnaires including relevant anthropological determinants such as human-animal interaction and risk behaviours, and laboratory analyses to detect and characterise pathogens (Kisoo, 2024) (Figure 26).

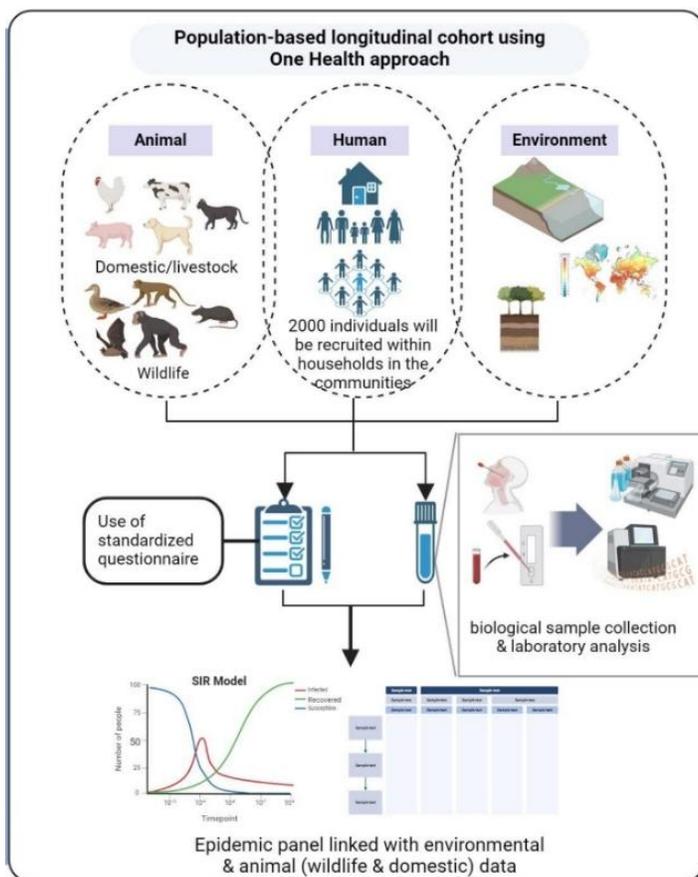


Figure 26 - Design of ELIPSA project – source: HIOH

In designing the ELIPSA project, a key priority is to ensure active community engagement across the entire cohort, as previously noted. Particular emphasis is also placed on ensuring that women’s voices are represented and heard within the study.

To support this, the study design includes the formation of three distinct focus group discussions for the cohort: women, men and young people. This approach enables women to express their perspectives in a space free from the presence of men, thereby fostering more open and inclusive dialogue.

The data collected will help assess which groups are more exposed to specific infectious agents or engage in behaviours that may increase such exposure. It will support an understanding of whether women are more vulnerable to zoonotic infectious agents due to differential exposure or underlying social and environmental determinants.

#### 6.4. Traineeship Experience within the ELIPSA Project: Creation of Questionnaires and SOP's in Animal Health Domain

The development of data collection tools for the animal health domain of the cohort study ELIPSA was included as part of the objectives of the traineeship. This project is structured around three interconnected domains - animal health, human health, and the environment and thus required the design of a longitudinal study encompassing all three areas, as illustrated in the diagram below (Figure 27).

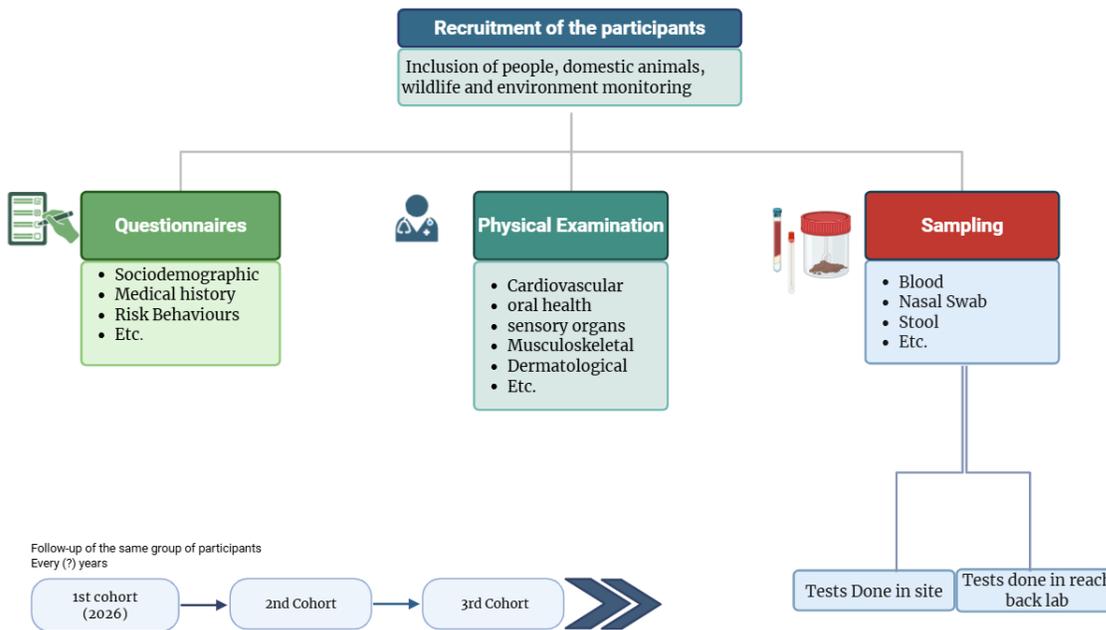


Figure 27 - Cohort study workflow

To support the implementation of the study within the animal health domain, the workflow was structured in accordance with the overarching ELIPSA framework and subsequently adapted to reflect the local socio-cultural context and realities of animal ownership and interaction in the communities involved.

The trainee was involved from the very beginning and had the responsibility to design and present the whole process to the supervising team. A detailed account of this process is provided in PART III.

## PART III – Development of One Health Content Through Physician Shadowing and Research Within ELIPSA Project

### 1. Summary and goals/objectives

The OH materials were developed during the curricular traineeship with the objective of creating digital tools both practical and user-friendly, intended not only for clinical application but also for research purposes, and, in some cases, for use by the general public.

Developed within the context of the traineeships at ULS São João and HIOH, these materials and tools materialised the knowledge and competences acquired and refined throughout the course of these placements.

A singular, standardised approach that is the same for everyone, in different work areas (health, education, food, etc.) simple doesn't work. That said, it is highly beneficial to develop tools, materials and guidelines that are more tailored and contextualized to specific, context of each country or region. It is therefore essential to create more flexible and more effective OH tools that can have an impact on all sectors and reach all communities (Barton Behravesh, 2019).

Given this, the OH materials developed during the traineeship highlight the importance of creating adaptable, context-specific tools to effectively address global health challenges. A flexible approach tailored to regional needs is essential for implementing and strengthening the OH strategy across sectors and combating shared threats such as zoonotic diseases and antimicrobial resistance. Hopefully, they will all be useful and effective.

### 2. Development of the “Guide to Travelling with Your Pet”

The guide entitled “*Guide to Travelling with Your Pet*” was developed as part of the traveller’s appointment follow-up activities and arose from a reflection on the concerns and recommendations typically provided to human travellers before, during, and after international travel.

The concept consisted of the trainee to design a form of ‘portable consultation’, a concise, informative leaflet, a handbook type of document, intended for individuals planning to travel

with their pets, outlining essential guidance to ensuring animal health and safety during travel, both printed and in a digital format.

The development was based on a comprehensive bibliographic review using platforms such as Google Scholar and PubMed, and by consulting reliable and official sources, including the WOA, the DGAV, the WHO, the European Commission, the *Diário da República*, the United States Animal and Plant Health Inspection Service, the *Yellow Book 2024*, the CDC, and the Federal Agency for the Safety of the Food Chain.

Although the original objective was to provide targeted information to individuals travelling with their pets at the traveller's appointment, the project broadens over time. Due to the format, easy reading and valuable information it contains, it has also been shared with the veterinary world, but also with the general public.

Initially, the guide was made available through the official website of ULS São João. To enhance its visibility and reach a broader audience, it was later disseminated via the official websites of both the DGAV and the Portuguese Veterinary Medical Association (OMV).<sup>1</sup> More recently, an adaptation of the Guide for the website PetBook was also provided.

The guide comprises six pages, including front and back covers, and contains clear, accessible information regarding the official documentation required for pet travel, necessary and recommended vaccinations, and preventive measures. It also includes general travel recommendations for pet owners, along with a glossary to facilitate reader comprehension. Please refer to the here included QR (Figure 28).



Figure 28 – QR code for the handbook - Guide to travel with your pet

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<sup>1</sup> Both the handbook and the infographics on the rational use of antimicrobials are available online at the following links (Official website of HLU São João and DGAV): <https://portal-chsj.min-saude.pt/comunidade/associacoes/one-health-sao-joao>; <https://hubram.dgav.pt/fao-apela-uma-acao-global-coordenada-one-health-contra-a-ram/>

### 3. Creating Evidence-Based Infographics on Rational Antimicrobial Use and Infection Control in Veterinary Practice: Companion and Production Animals

Following close observation of the work undertaken by the IDD and UPCIRA teams and recognising the relevance and impact of its contribution, the idea was to develop a similar resource aimed at supporting veterinary professionals, analogous to the tools available in human medicine, when confronted with infections in clinical practice.

In response, two informational posters were created, designed to highlight the most critical elements of effective infection control and the safe, evidence-based prescription of antimicrobials.

In order to develop the posters, an extensive literature review and online research were conducted using authoritative sources. These included official websites and publications from institutions such as the European Medicines Agency, Infarmed, DGAV, the National Institute for Agrarian and Veterinary Research/ Instituto Nacional de Investigação Agrária e Veterinária (INIAV), WOAHA, the British Veterinary Association, and the World Small Animal Veterinary Association.

The content was based on European Union-level strategies and guidelines on antimicrobial stewardship, including the One Health National Action Plan on AMR, the EU4Health Programme, and regulatory frameworks addressing veterinary medicinal residues and environmental surveillance. Relevant legislative instruments, such as EU directives and decree-laws, governing the use of veterinary medicinal products in Portugal, were also consulted.

Additional reference materials included infographics and technical documents on topics such as the categorisation of veterinary medicinal products, prudent antimicrobial use guidelines were reviewed. Practical frameworks like the BVA's 7-Point Plan for the responsible use of antimicrobials in veterinary practice and WSAVA's "Six Moments of Veterinary Antimicrobial Prescribing" were also incorporated.

Other key reports contributing to the understanding of AMR dynamics were consulted<sup>2</sup>.

These materials address the rational use of antimicrobials within veterinary clinical practice, covering both companion animals and livestock. The posters are titled '*Rational Use of Antimicrobials and Infection Control in One Health for Companion Animals*' and '*On-Farm Strategies and Rational Use of Antimicrobials and Infection Control in One Health for Production Animals*'.

These resources contain evidence based, rigorous, clear, accessible guidance intended for veterinary surgeons, available in both printed and digital formats. Included within the posters are practical checklists and key questions to consider when managing infections, as well as information on appropriate antimicrobial prescription during surgery, critical decision-making points for antimicrobial use, and examples of antimicrobials that should be avoided in clinical settings. Please refer to the here included QR (Figure 29).<sup>3</sup>

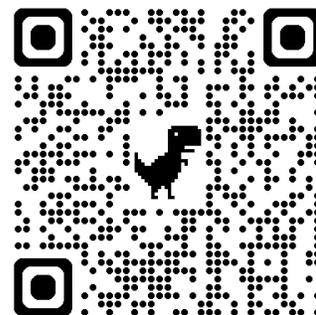


Figure 29 – QR code for infographics on the topic AMS and IPC in veterinary medicine

#### 4. Production of Questionnaires and SOP's for the ELIPSA Project

As outlined in Chapter VI, Part II, the ELIPSA project constitutes a cohort study designed to establish an epidemic panel employing a comprehensive and integrated One Health approach in Ivory Coast and Central African Republic.

As mentioned before, within the scope of the second component of the traineeship, the task was assigned to define and enhance the relevant parameters for data collection concerning animal health, with a specific focus on domestic animals.

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<sup>2</sup> (Official Journal of the European Union, 2023); (Jornal oficial da União Europeia, 2019); (Official Journal of the European Communities, 2001); (Direção-Geral de Alimentação e Veterinária, 2025); (Official Journal of the European Union, 2015); (Gabinete de Planeamento, Políticas e Administração Geral, 2020); (DGAV, 2021); (*Veterinary Good Pharmacovigilance Practices (VGVP)* | *European Medicines Agency (EMA)*, 2009); (BVA, 2019); (WSAVA, 2023); («HealthforAnimalsRoadmap Progress Report 2023 |», 2023); (O'Neill, 2014); (Gomes, 2021); (WOAH, 2016); (WHO et al., 2022)

<sup>3</sup> Both the handbook and the infographics on the rational use of antimicrobials are available online at the following links: <https://portal-chsj.min-saude.pt/comunidade/associacoes/one-health-sao-joao>; <https://hubram.dgav.pt/fao-apela-uma-acao-global-coordenada-one-health-contra-a-ram/>

Each participant will be interviewed, by asking questions regarding all animals present in their household (e.g., “Do your livestock come into contact with wildlife?”). Subsequently, a randomly selected subset of animals per household will be the subject of individualised questions (e.g., “Does this animal show any signs of disease?”, “Were there any presence of parasites within the past three months”).

In addition to the data obtained through these community questionnaires, physical examinations and biological sampling will serve as further sources of key data within this longitudinal study.

Samples include blood, faeces, and nasal swabs. Physical examinations will be conducted on a designated number of animals per household. These physical examinations will assess parameters such as respiratory rate and the presence of dermatological abnormalities, including abscesses, for example.

Complementary to this task was the participation in the creation of SOPs for the physical examination and sampling of domestic animals.

In May 2025, the ELIPSA team was scheduled to visit local communities surrounding Tai National Park in Ivory Coast, with the objective of testing both the questionnaires and the developed SOPs for animal health data collection.

Following this field visit and based on the feedback, a phase of revision and re-evaluation will be initiated. This phase will involve a multidisciplinary group of experts from human health, animal health, and environmental sciences - including physicians, veterinary surgeons, biologists, epidemiologists, and ecologists - to finalise the content of both the questionnaires and the SOPs.

Subsequently, the finalised questionnaire will be integrated into a digital platform, specifically the Open Data Kit (ODK) - an open-source mobile data collection tool. The ODK platform allows forms to be completed offline and submitted once internet connectivity is restored. Once uploaded, the data can be accessed, analysed, and acted upon via a central server.

In the fourth phase, a pre-test of the definitive questionnaire will be conducted in the field, likely between November 2025 and January 2026.

The full and first cohort study is scheduled to start in February 2026 in Ivory Coast, and involves applying the questionnaires, implementing the physical examinations, and the collection of samples within the participating communities.

#### 4.1. Development of Questionnaire Items and Physical Examination Metrics for Data Collection

An Excel document was developed for the insertion and organisation of all questions related to the animal health and physical examination components of the ELIPSA questionnaire.

This template, originally designed by the Data Management Department, was structured to align with the ODK format, thereby facilitating the later digital integration of the content.

Between January and March 2025, questions addressing animal health for inclusion in the ELIPSA questionnaires were systematically researched, designed and compiled. This process involved targeted online searches using relevant key terms such as “*One Health in Western Africa*”, “*cohort study in Western Africa*”, “*One Health surveillance in Western Africa*”, “*epidemiology of zoonoses in Africa*”, “*zoonotic surveillance in Africa*”, “*tuberculosis in Western Africa*”, “*brucellosis in Africa*”, “*listeriosis in Africa*” and “*risk behaviours for zoonosis*”.

Validated resources were also consulted to inform questionnaire development, most notably the IDEAL PROJECT - *Infectious Diseases of East to African Livestock*, (The Ideal Project, 2025, February, 03) and the RHOMIS - *Rural Household Multi-Indicator Survey* (RHOMIS, 2025, February, 04). Due to their scientific rigour and relevance, these sources are further elaborated below, given their significant contribution to the content of the ELIPSA questionnaires.

The IDEAL Project monitored 548 calves from birth up to 51 weeks of age - or until illness or death - aiming to explore infectious disease dynamics in East African cattle populations.

The scientific goals were to quantify the infectious disease burden in East African calves over a three-year period; to evaluate and improve diagnostic tools under field conditions; to assess the interactions of multiple infections; to identify risk factors for mortality, morbidity, and stunting; and to correlate outcomes with genetic, immunological, and nutritional indicators. A comprehensive biobank and data archive were also established for future research (The Ideal Project, 2025, February 03).

The RHoMIS - *Rural Household Multi-Indicator Survey*, was designed to standardise and enhance data collection from smallholder farming households in low-resource settings. In contrast to conventional surveys, which often yield inconsistent datasets, RHoMIS combines a suite of standardised metrics with flexible design to improve cross-study comparability. Its core modules focus on farming practices, livelihoods, and food security (RHoMIS, 2025, February, 04).

The trainee was involved in the creation of all above-mentioned questionnaires for the ELIPSA project. To ensure scientific rigour and contextual relevance, the development of the questionnaire content was monitored by regular meetings with Dr Filipe Dias, during which the drafted questions were thoroughly analysed and reviewed.

Additional consultations/meetings were held with the Data Management Department, subject-matter experts from the Innodia project, two PhD students in epidemiology, and a microbiologist from the Friedrich-Loeffler-Institut (FLI).

The Excel document comprises two sheets: the first, titled *DataDictionary*, includes all formulated questions, including those for physical examinations. The second sheet, *SpecialLists*, provides predefined lists of relevant veterinary terms, including vaccines, medications, injuries, exudates, and diseases. Each question is accompanied by its corresponding bibliographic reference.

In total, the initial compilation comprises 450 questions designed for the animal health questionnaire. These cover multiple thematic categories and include sub-questions addressing various species, including cattle, sheep/goats, pigs, cats, dogs, poultry, and guinea pigs (Figure 30).

			1 - daily 2 - at least once a week 3 - at least once a month 4 - at least every 6 months 5 - at least once a year 6 - more rarely 7 - never 8 - ND
How often are your animals in contact with wild animals?		select_one list_name	
If yes, which ones?		select_multiple list_name	1 - cattle 2 - sheeps 3 - goats 4 - pigs 5 - chickens 6 - dogs 7 - ginea pigs
What species of wild animals?		text	list of wild animals
Does this contact vary over the year?		select_one list_name	1 - yes, more in dry season 2 - yes, more in wet season 3 - no 4 - ND
How is the contact?		select_multiple list_name	1 - through bites or fights 2 - social contact (share the place of feed or shelter or rest or water...) 3 - through sexual contact
Where the contact can happen?		select_multiple list_name	1 - in the forest 2 - in forest edge 3 - in the village 4 - all places

Figure 30 – Examples of Questions to the communities related to animal health

Questions can be divided into 2 subcategories regarding their categories:

- questions at the household level (Figure 31)
- questions at the individual level (Figure 32)

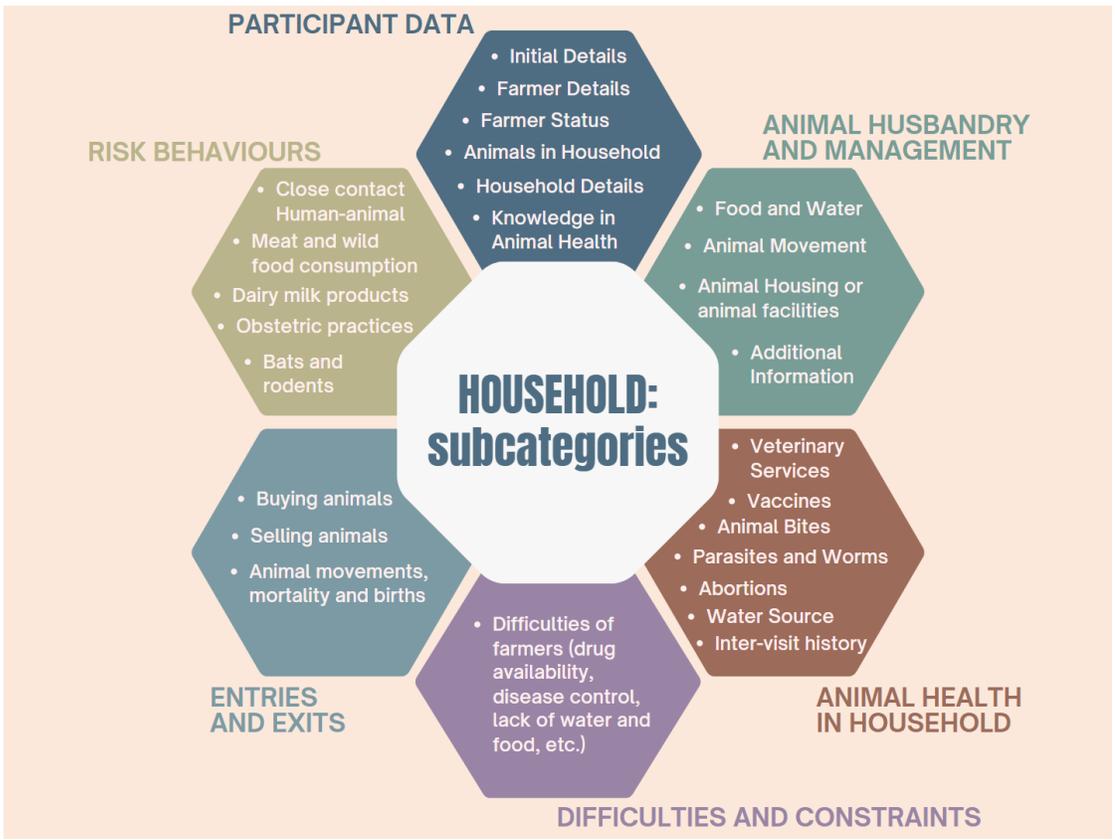


Figure 31 - Household Subcategories

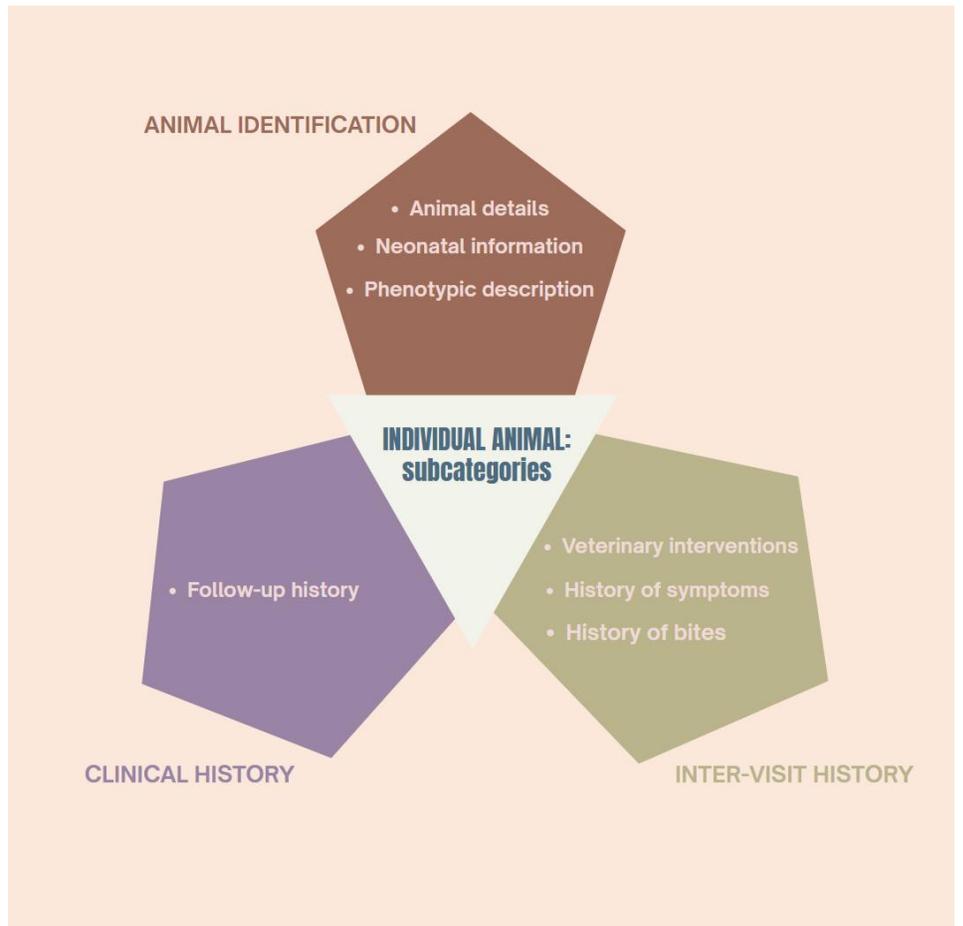


Figure 32 - Individual Animal subcategories

Within the same Excel document, the animal health questions pertaining to the physical examination component of the ELIPSA project were developed between February and March 2025. This process was informed by an extensive literature review, drawing on materials from the SHIP One Health documentation, as well as previously consulted sources such as the IDEAL Project and the RHoMIS Survey.

The decision to consolidate both the animal health questionnaire and the physical examination checklist into a single document was taken to streamline the workflow for field technicians. This integrated approach enables the same technician to collect interview-based information from animal owners and conduct the physical examination, thereby increasing operational efficiency.

The physical examination section includes a total of 165 closed questions and sub-questions. Above there are some examples of questions regarding to the physical examination (Figure 33). These items are being prepared for inclusion in a digital data collection tool, alongside the broader questionnaire administered to community members. The digital platform will allow technicians to perform physical examinations with the guidance of SOPs, which will be detailed later, and to enter results directly and efficiently.

silhouette, conformation and position of udder			select_multiple list_name	6 - no abnormalities 7 - other 8 - ND
ocular			select_one list_name	1 - none 2 - mild 3 - profuse 4 - ND 5 - NA
ocular	If abnormal select type of discharge from list in Speciallists [code]		decimal	____ (list of discharges and exudates)
nasal			select_one list_name	1 - none 2 - mild 3 - profuse 4 - ND 5 - NA
nasal	If abnormal select type of discharge from list in Speciallists [code]		decimal	____ (list of discharges and exudates)
ear			select_one list_name	1 - none 2 - mild 3 - profuse 4 - ND 5 - NA
ear	If abnormal select type of discharge from list in Speciallists [code]		decimal	____ (list of discharges and exudates)

Figure 33 - Examples of Questions regarding to the physical examination

To assist with accurate, for example, lesion identification, relevant questions within the digital tool will be supplemented with reference images depicting typical pathological findings. These images will correspond to those included in the SOPs textbook for physical examination, which will also be discussed in a subsequent section. The clinical signs described in the SOPs manual will be translated into structured, closed-ended questions within the digital tool, ensuring consistency and ease of use during fieldwork.

#### 4.1.1. Subcategories for the Questions for the Physical Examination

The subcategories are (Figure 34):

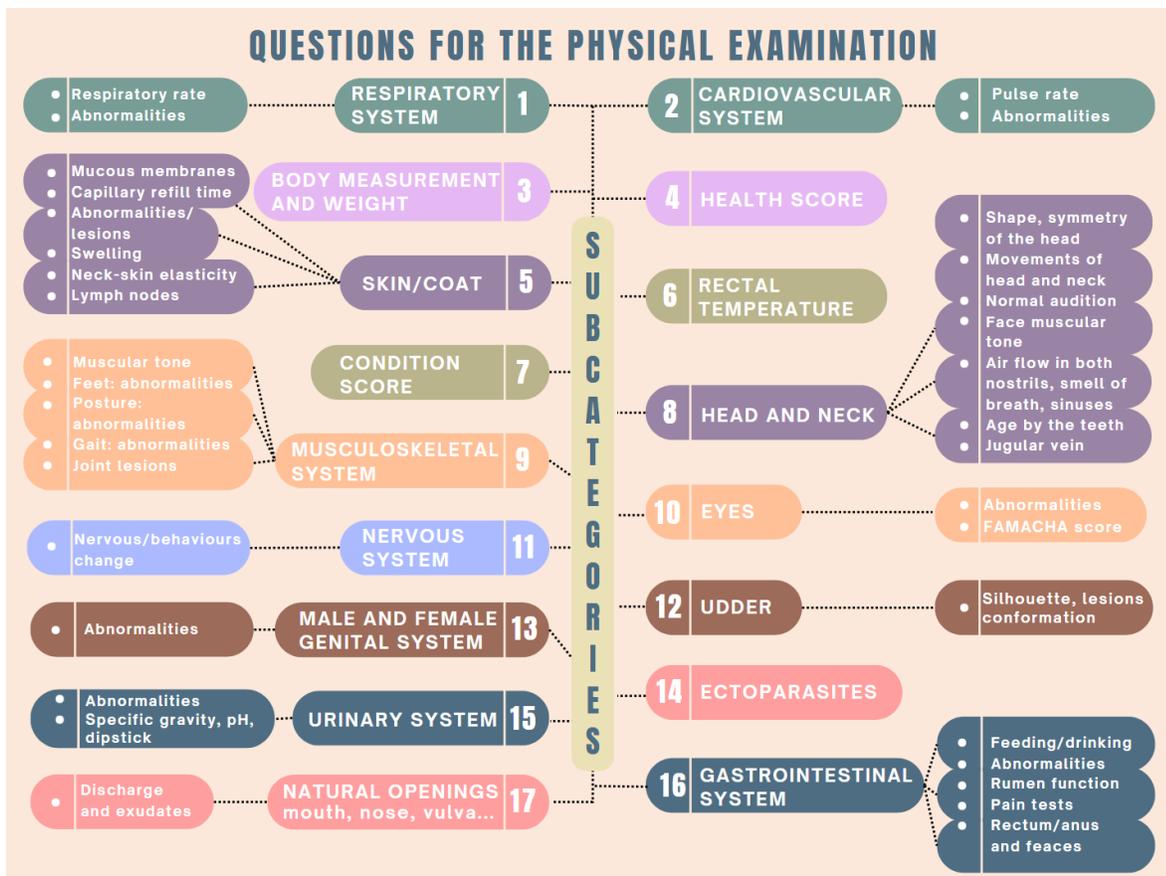


Figure 34 – Questions Subcategories for the physical examination

## 4.2. Creation of the SOP's for the Physical Examination

The development of SOPs for the physical examination of domestic animals within the ELIPSA project was undertaken between February and March 2025. This work was based on a literature review that included materials from the SHIP One Health initiative, the IDEAL and RHoMIS projects, as well as veterinary textbooks on physical and clinical examination.

The SOPs for physical examination produced for this project include comprehensive protocols applicable to the examination of various domestic species - namely cattle, sheep, dogs, cats, and pigs - selected based on their relevance to zoonotic infectious disease surveillance.

The final SOP document consists of 78 pages, with content systematically organised by anatomical region. With 23 chapters, each chapter contains detailed instructions supported by visual aids for all the procedures, and all sources of information and images are fully referenced.

Above there are two examples of SOPs for the physical examination. (Figure 35)

### Dogs and cats

1. Make sure your thermometer works and is on.
2. Apply a lubricant to the tip of the thermometer. This is not required, but it can make it more comfortable for your dog. If you do not have any water-soluble lubricant at home, petroleum jelly, Vaseline, or coconut oil will all work just as well.
3. Ideally, have someone else help you hold your dog. Most dogs will find the thermometer surprising, and some do not like having their temperature taken. It is safer to have someone help to hold your dog so that they do not turn around and bite you if taken by surprise
4. Lift your dog's tail and insert the tip of the thermometer into the anus approximately 2,5 cm and in a 30 degree angle
5. When the thermometer beeps (if using digital) or after 60 seconds (if using mercury), remove the thermometer and read the temperature.

*Figure 35 - SOPs for physical examination - example*



### 4.3. Creation of SOP's for Sampling Collection

The SOPs for the collection of biological samples from domestic animals under the ELIPSA project were developed between February and March 2025. The preparation of these documents was informed by an extensive literature review, incorporating resources from the SHIP One Health project, the IDEAL project, and the PREDICT initiative.

PREDICT is an initiative under USAID's Emerging Pandemic Threats Programme and has played a key role in strengthening global early warning systems designed to identify and mitigate emerging zoonotic diseases (Ohe Health Institute, University of California, 2020).

The SOPs were developed using a standardised template provided by HIOH.

The QR code (Figure 36) links to a merged document, totalling four pages, containing the HIOH template for a SOP, applicable to any sampling collection, with two pages, and a two-page excerpt from a SOP developed by the trainee.

Each SOP was compiled as an individual Word document, encompassing detailed guidelines for the sampling of a range of domestic animal species - namely cattle, sheep, pigs, dogs, and cats - with particular attention to procedures relevant for the surveillance of zoonotic infectious diseases.

A total of 20 SOPs were produced. All textual content and visual materials are appropriately referenced. The inclusion of illustrative images within each SOP is intended to support technicians in accurately performing the specified sampling techniques.

The SOPs were categorised into two main sections: (1) routine biological sample collection from clinically healthy animals and (2) sample collection associated with specific clinical presentations or suspected disease episodes.



*Figure 36 - SOP's for sampling collection - HIOH template and example*

### 4.3.1. Compulsory Biological Sample Collection from Live Animals

In this category we divided the SOPs per each one of the reference species, livestock, the dogs and cats and poultry (Figure 37 and Figure 38).

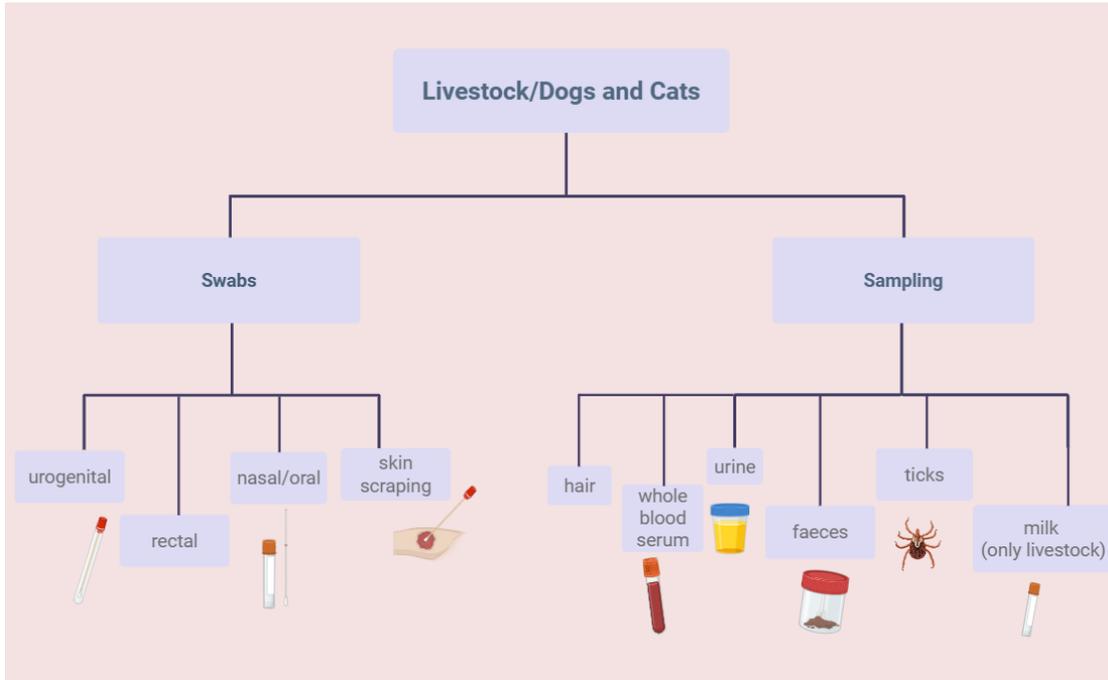


Figure 27 - SOPs for sampling collection for livestock and companion animals

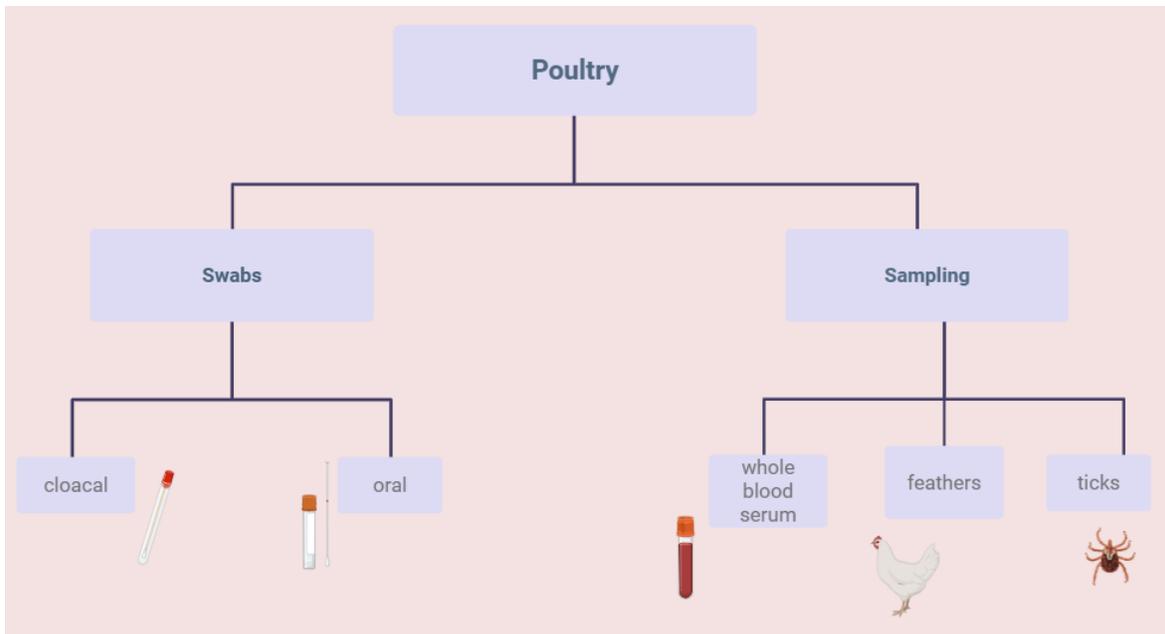


Figure 38 - SOPs for sampling collection for poultry

#### 4.3.2. Biological Samples Collection from Clinical Episodes

This category comprises three SOPs: one for the collection of biopsies, one for lymph node aspiration, and one for the collection of swabs from exudates and discharges. These SOPs were specifically developed for situations in which animals present with clinical abnormalities such as skin lesions, abscesses, exudates, or other discharges (Figure 39).

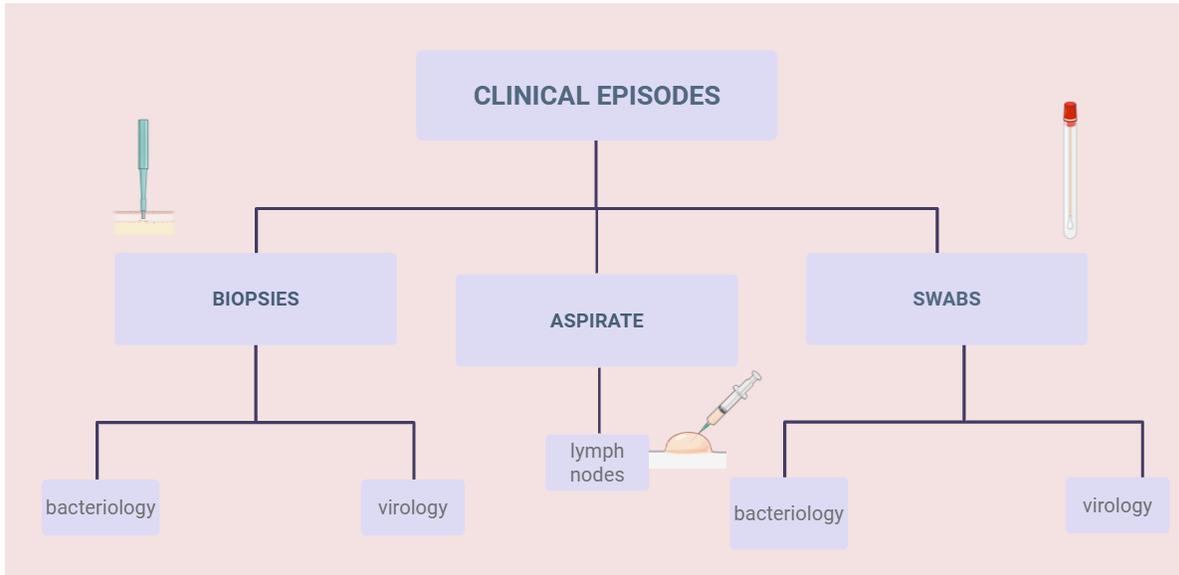


Figure 39 - SOPs for clinical episodes

Upon completion of the traineeship, a status report was prepared, detailing all information regarding the documents produced and the progress achieved to date. This was intended to facilitate more efficient communication within the team concerning completed tasks and outstanding activities.

## Discussion

This OH traineeship model, integrated into Veterinary Medicine degree programme as the final curricular traineeship, proved to be effective from an educational perspective, enabling the acquisition and consolidation of competencies relevant to future professional practice.

The educational effectiveness of the traineeship is supported by the range of activities and outputs developed throughout its duration, which are reflected in this dissertation. These include the production of infographics addressing the areas observed and explored during the traineeship, as well as the development of data collection tools within the scope of the ELIPSA project, whose applicability of both extends beyond the traineeship period.

Transdisciplinary work constituted a central component of this traineeship and was applied across multiple contexts. Intellectual competencies were developed, as demonstrated through participation in interinstitutional and interdepartmental meetings at both ULS São João and HIOH, as well as through involvement in awareness-raising sessions delivered to primary and secondary school students.

Regarding the epidemiology of zoonotic diseases, technical knowledge was acquired and further developed at both national and international levels, particularly in the context of countries in sub-Saharan Africa. This knowledge was contextualised within the relevant socioeconomic, environmental, and cultural frameworks, allowing for an integrated understanding of the determinants of health from a OH perspective.

Concerning the rational use of antimicrobials and IPC, knowledge in these areas was similarly consolidated and expanded, primarily within the field of human medicine. A critical reflection was undertaken regarding the potential replicability of these practices within veterinary medicine.

This process resulted in the development of infographics focused on AMS and IC in both companion animal and production animal clinical settings.

Another example of the traineeship's educational effectiveness was the involvement in the traveller's health consultation, which led to the creation of a handbook entitled *Guide for Travelling with Your Companion Animal*. This document compiles key recommendations to be considered when travelling with companion animals.

Furthermore, the tools developed for data collection within the ELIPSA project reflect the work carried out during the traineeship period at the HIOH. This work was characterised by a strong OH component, grounded in a multisectoral, interdisciplinary, and transdisciplinary approach, within a research institute whose mission is fully aligned with the OH framework.

Critical reflection on existing gaps in health-related training, combined with the development of effective models and instruments in the areas as antimicrobial prescribing and monitoring, IPC, OHS systems supports the consideration of this traineeship model as potentially replicable across different health disciplines.

Despite the positive outcomes observed, certain limitations were identified, namely the limited practical application of veterinary clinical technical skills, as the traineeship was primarily based on an observational and descriptive study design.

Nevertheless, the knowledge acquired was significantly deepened, contributing to the training of a veterinary professional with a broader and more integrative perspective, equipped with competencies in areas such as local and global epidemiology, relevant legislation, and collaborative work within a One Health framework, among other areas previously described.

## Conclusion

As a student of Veterinary Medicine and a future public health professional, this traineeship has provided paramount insight into the breadth and critical importance of Veterinary Medicine in promoting overall health.

From the perspective of a trainee, considerable interdisciplinary knowledge was acquired, particularly regarding the OH concept. The inclusion of similar experiences in both medical and veterinary *curricula* would be highly beneficial for all students in the field.

It is of the utmost importance that multiple sectors collaborate harmoniously from an early stage to achieve a shared objective, the health and well-being of all. From the outset of their studies, veterinary students should be exposed to the complexities of the human–animal–environment interface through collaborative, transdisciplinary and multisectoral learning.

Such an approach would enable students to develop the intellectual competencies necessary to consistently and permanently apply the OH framework. It is important to highlight that, in this context, skills such as effective communication, inclusivity, active engagement, and open-mindedness are also absolutely essential for advancing this path.

In light of this, it is essential that veterinary school *curricula*, whether through formal and non-formal education, integrate opportunities for close collaboration with disciplines such as human medicine, epidemiology, ecology, and related fields.

In fact, it is acknowledged that all individuals could benefit from some degree of training in this area, given its relevance to all living beings on the planet. Education and awareness initiatives concerning OH should be prioritised and made accessible to all demographics, ranging from children to adults, from educators to students, from physicians to technical and auxiliary staff. Health is a collective good.

During awareness sessions conducted in schools throughout the traineeship, a clear need for instruction in this area was identified. Such efforts contribute to the development of an

informed population and foster a sense of shared responsibility in driving positive change for a safer planetary health.

The OH approach should be universal and integrated across all fields of study, from health sciences to engineering, education, and law. By equipping individuals with the capacity to work collaboratively across sectors, disciplines, and communities in a unified manner focused on the common good - human, animal, and environmental well-being -sustainable development may be fostered across diverse institutions, be it companies, hospitals, or schools (Winkler et al., 2025).

Given the role of veterinary professionals as public health agents, OH education should be regarded as imperative within all health-related academic programmes. Only through such comprehensive training can a truly holistic model of health for all be achieved. Interdisciplinary collaboration between healthcare fields should begin during professional training and continue throughout one's career.

At the Universidad Peruana Cayetano Heredia, veterinary medicine students are required to complete a clinical rotation in Infectious and Tropical Diseases at the Hospital Nacional Cayetano Heredia. As in this example, such interdisciplinary exchange is considered replicable in other countries and could even be reversed, with veterinary medicine contributing to the training of young medical doctors as well, under the OH framework. This requisite facilitates a complete exchange of knowledge in overlapping areas of both disciplines, including risk behaviours, biosafety, and preventive medicine, particularly in the field of education.

Preventive medicine remains the most effective strategy for the promotion of health. Multiple avenues of preventive action may be pursued, including direct community engagement through educational initiatives beginning in childhood (covering topics such as vaccination, hygiene, and food safety), as well as vaccination campaigns targeting both human and animal populations to mitigate outbreaks and the spread of infectious diseases.

In addition, public health contributions through food safety or research into novel vaccines and epidemiological surveillance systems further reinforce the preventive framework. Investment in preventive medicine is inherently an investment in the OH model.

Drawing on the example of the OHSJG, the establishment of a similar structure within veterinary medicine would be both beneficial and timely. Ideally, collaborative integration of OH teams from both human and veterinary medicine could be pursued. By establishing this team and replicating the activity types, communication strategies, and community engagement models utilised by OHSJG, characterised by multidisciplinary and intersectoral collaboration, the realisation of OH outcomes become increasingly attainable.

Regarding AMS, further development and refinement of the veterinary model are warranted. Insights from the UPCIRA team could serve as a foundation for progress in this domain. Establishing a UPCIRA-equivalent team dedicated to both companion and production animals would contribute to the reduction of inappropriate antibiotic use and lower antimicrobial resistance rates within animal health contexts.

Another avenue for enhancing the OH approach in Portugal would involve treating zoonoses as a shared concern between veterinary and human medicine. A shared laboratory, and a dedicated common notification system for the diagnosis of zoonotic diseases should be established to facilitate data integration and information exchange between disciplines. This would enable more effective prevention and treatment based on a true OH model.

Moreover, the implementation of an OHS System, as demonstrated by the ELIPSA project and the work at HIOH, would provide enhanced capacity to identify and monitor key threats to global health at regional, national, and international levels. The collaboration of all members of the community, from healthcare professionals or researchers to general public, would be essential, thereby streamlining efforts in disease prevention and preparedness.

In summary, the traineeship experience reinforces the essential role of Veterinary Medicine within the OH framework. Embedding OH principles into veterinary education and health-related *curricula* is imperative to equip future professionals with the skills and competences needed for effective, preventive, and sustainable health strategies.

## Bibliography:

- Aarestrup, F. M., Bonten, M., & Koopmans, M. (2021). Pandemics– One Health preparedness for the next. *The Lancet Regional Health – Europe*, 9. <https://doi.org/10.1016/j.lanepe.2021.100210>
- Addis, M., Bitew, A., & Ibrahim, N. (2016). One Health Approach to Prevent Emergence and Spread of Emerging Zoonoses. *Food Science and Quality Management*, 49, 53–62.
- Alakunle, E., Kolawole, D., Diaz-Cánova, D., Alele, F., Adegboye, O., Moens, U., & Okeke, M. I. (2024). A comprehensive review of monkeypox virus and mpox characteristics. *Frontiers in Cellular and Infection Microbiology*, 14. <https://doi.org/10.3389/fcimb.2024.1360586>
- Anderson, M. E. C. (2015). Contact Precautions and Hand Hygiene in Veterinary Clinics. *Veterinary Clinics of North America: Small Animal Practice*, 45(2), 343–360. <https://doi.org/10.1016/j.cvsm.2014.11.003>
- AnimalhealthEurope | Animal Diseases preparedness (2025a, janeiro 28). *AnimalhealthEurope*. <https://animalhealtheurope.eu/resources/papers/animal-disease-preparedness/>
- AnimalhealthEurope | Disease Prevention (2025b, dezembro 16). *AnimalhealthEurope*. <https://animalhealtheurope.eu/focus-areas/disease-prevention/>
- AnimalhealthEurope | Establishing a dialogue for Animal Disease Prevention, Preparedness and response (2025c, janeiro 29). *AnimalhealthEurope*. <https://animalhealtheurope.eu/about-us/annual-reports/2024-2/establishing-a-dialogue-for-animal-disease-prevention-preparedness-and-response/>
- Antimicrobial use in veterinary practice* | American Veterinary Medical Association. (2025). <https://www.avma.org/resources-tools/one-health/antimicrobial-use-and-antimicrobial-resistance/antimicrobial-use-veterinary-practice>
- Ateudjieu, J., Siewe Fodjo, J. N., Ambomatei, C., Tchio-Nighie, K. H., & Zoung Kanyi Bissek, A.-C. (2023). Zoonotic Diseases in Sub-Saharan Africa: A Systematic Review and Meta-Analysis. *Zoonotic Diseases*, 3(4), Artigo 4. <https://doi.org/10.3390/zoonoticdis3040021>
- Barton Behravesh, C. (2019). *Introduction. One Health: Over a decade of progress on the road to sustainability*. 38(1), 21. <https://doi.org/10.20506/rst.38.1.2939>
- Bastos, C. (2023). *Isolamento*. <http://hdl.handle.net/10400.26/46466>
- Bath, G. F., Penrith, M. L., & Leask, R. (2016). A questionnaire survey on diseases and problems affecting sheep and goats in communal farming regions of the Eastern Cape province, South Africa. *J S Afr Vet Assoc*, 87(1), e1-e10. <https://doi.org/10.4102/jsava.v87i1.1348>
- Berezowski, J., Akkina, J., Del Rio Vilas, V., DeVore, K., Dórea, F.C., Dupuy, C., Maxwell, M.J., Singh, V.V., Vial, F., Contadini, F.M., & Streichert, L.C. (2019). *One Health Surveillance: Perceived benefits and workforce motivations*. 38(1), 251. <https://doi.org/10.20506/rst.38.1.2957>
- Bernardo, F. M. A., & Cardo, M. (2017). *Introdução ao estudo de Inspeção Sanitária*.

- BVA, B. V. A. (2019). *Responsible use of antimicrobials in veterinary practice poster*. British Veterinary Association. <https://www.bva.co.uk/resources-support/medicines/responsible-use-of-antimicrobials-in-veterinary-practice-poster/>
- Carugati, M., Kilonzo, K. G., & Crump, J. A. (2019). Fever, bacterial zoonoses, and One Health in sub-Saharan Africa. *Clinical Medicine*, 19(5), 375–380. <https://doi.org/10.7861/clinmed.2019-0180>
- CDC. (2024, novembro 21). *About One Health*. One Health. <https://www.cdc.gov/one-health/about/index.html>
- CDC. (2025, junho 25). *The Yellow Book*. Yellow Book. <https://www.cdc.gov/yellow-book/hcp/contents/index.html>
- Chala, B., & Hamde, F. (2021). Emerging and Re-emerging Vector-Borne Infectious Diseases and the Challenges for Control: A Review. *Frontiers in Public Health*, 9. <https://doi.org/10.3389/fpubh.2021.715759>
- Christmann, U. (2020). *Best practices in veterinary personal protective equipment*. 39(2), 561. <https://doi.org/10.20506/rst.39.2.3107>
- Clara, A., Ndiaye, S. M., Joseph, B., Nzogu, M. A., Coulibaly, D., Alroy, K. A., Gourmanon, D. C., Diarrassouba, M., Toure-Adechoubou, R., Houngbedji, K. A., Attiey, H. B., & Balajee, S. A. (2020). Community-Based Surveillance in Côte d'Ivoire. *Health Security*, 18(S1), S-23-S-33. <https://doi.org/10.1089/hs.2019.0062>
- Cunningham, A. A., Daszak, P., & Wood, J. L. N. (2017). One Health, emerging infectious diseases and wildlife: Two decades of progress? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 372(1725), 20160167. <https://doi.org/10.1098/rstb.2016.0167>
- Day, M. J., Horzinek, M. C., Schultz, R. D., & Squires, R. A. (2016). WSAVA Guidelines for the vaccination of dogs and cats. *The Journal of Small Animal Practice*, 57(1), E1–E45. [https://doi.org/10.1111/jsap.2\\_12431](https://doi.org/10.1111/jsap.2_12431)
- Dias, F. W., Oby; Kouadio, Léonce; Leendertz, Fabian; Zimmermann, Fee. (2024). A participatory approach for the establishment of a One Health cohort study in Côte d'Ivoire. International One Health Symposium 2024, Mercure Hotel MOA Berlin.
- DGAV. (2021). *Estratégias da exploração para o combate à resistência aos antimicrobianos*. [https://www.dgav.pt/wp-content/uploads/2021/03/resistencia\\_micro-Estrategias-na-Exploracao.pdf](https://www.dgav.pt/wp-content/uploads/2021/03/resistencia_micro-Estrategias-na-Exploracao.pdf)
- DGS. (2019). *Higiene das Mãos nas Unidades de Saúde—Portal das Normas Clínicas*. <https://normas.dgs.min-saude.pt/2019/10/16/higiene-das-maos-nas-unidades-de-saude/>
- Direção-Geral de Alimentação e Veterinária. (2025). *Categorização dos antibióticos utilizados em animais para uma utilização prudente e responsável*. [https://www.dgav.pt/wp-content/uploads/2021/03/infographic-categorisation-antibiotics-use-animals-prudent-responsible-use\\_pt.pdf](https://www.dgav.pt/wp-content/uploads/2021/03/infographic-categorisation-antibiotics-use-animals-prudent-responsible-use_pt.pdf)

do Vale, B., Lopes, A. P., Fontes, M. da C., Silvestre, M., Cardoso, L., & Coelho, A. C. (2021). A Cross-Sectional Study of Knowledge on Ownership, Zoonoses and Practices among Pet Owners in Northern Portugal. *Animals*, 11(12), Artigo 12. <https://doi.org/10.3390/ani11123543>

Douglas, K. (2025, janeiro 21). *Biosecurity for Sustainable Development: A cornerstone for global progress - The Animal Echo*. <https://theanimalecho.woah.org/en/biosecurity-for-sustainable-development/>

Eberhard, J. M. H., James, H., Lux, L., Brendecke, J., Essen, S., Paditz, M., Bläsing, D., Lübcke, P., Ulrich, M., Nowak, K., Stoek, F., Gierse, L., Röhrs, S., Maksimov, A., Korthase, C., Zimmerman, F., Schaufler, K., Gogarten, J. F., Cavignac-Spencer, S., Leendertz, F. (2024). CiFly – a fly-based Citizen Science project with pupils to monitor mammal biodiversity and anti-microbial resistance (AMR). International One Health Symposium 2024, Mercure Hotel MOA Berlin.

ECDC. (2012, maio 31). *Listeriosis*. <https://www.ecdc.europa.eu/en/listeriosis>

ECDC. (2023). *Antimicrobial resistance surveillance in Europe 2023—2021 data*. <https://www.ecdc.europa.eu/en/publications-data/antimicrobial-resistance-surveillance-europe-2023-2021-data>

ECHA. (2013). *Understanding BPR - ECHA*. <https://echa.europa.eu/regulations/biocidal-products-regulation/understanding-bpr>

EFSA, E. F. S. & ECDC. (2024). The European Union One Health 2023 Zoonoses report. *EFSA Journal*, 22(12), e9106. <https://doi.org/10.2903/j.efsa.2024.9106>

Elisha, I. L., Onikisateinba, A., Joel, G. S., Luka, P. D., Joshua, B. I., Jagab, S. H., Ahmed, R., Haliru, H., Abubakar, S. A., Makama, S., Sati, N. S., & Muhammad, M. (2024). Unveiling the global reach of African anthrax research: A bibliometric study. *Science in One Health*, 3, 100052. <https://doi.org/10.1016/j.soh.2023.100052>

Ellwanger, J. H., & Chies, J. A. B. (2021). Zoonotic spillover: Understanding basic aspects for better prevention. *Genetics and Molecular Biology*, 44(1 Suppl 1), e20200355. <https://doi.org/10.1590/1678-4685-GMB-2020-0355>

FAD PRoP/NAHEMS. (2011). *NAHEMS GUIDELINES: PERSONAL PROTECTIVE EQUIPMENT (PPE)*.

[https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.cfsph.iastate.edu/pdf/fad-prep-nahems-guidelines-ppe-personal-protective-equipment&ved=2ahUKEwiqr96LrKiNAxX6S\\_EDHfgHClUQFnoECBYQAQ&usg=AOvVaw0hc0sSqjmPVd2aOs3iMM0z](https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.cfsph.iastate.edu/pdf/fad-prep-nahems-guidelines-ppe-personal-protective-equipment&ved=2ahUKEwiqr96LrKiNAxX6S_EDHfgHClUQFnoECBYQAQ&usg=AOvVaw0hc0sSqjmPVd2aOs3iMM0z)

FAO, UNEP, WOA, & WHO. (2022). *One Health Joint Plan of Action (2022-2026). Working together for the health of humans, animals, plants and the environment*. Rome. <https://doi.org/10.4060/cc2289en>

FAO, WOA, & WHO. (2019). *Taking a multisectoral, one health approach: A tripartite guide to addressing zoonotic diseases in countries*. <https://www.who.int/publications/i/item/9789241514934>

FDA Centre for Veterinary Medicine. (2023). *Supporting Antimicrobial Stewardship in Veterinary Settings*. [https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.3tres3.com.pt/3tres3\\_common/art/pt/16353/fixters/Supporting-Antimicrobial-Stewardship-in-Veterinary-Settings\\_FY24-28\\_final.pdf&ved=2ahUKewi4lInky9iPAxWQVKQEHQ\\_qBawQFnoECCgQAQ&usq=A0vVaw2fk24-QbE1gG9e6VPVDzjm](https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://www.3tres3.com.pt/3tres3_common/art/pt/16353/fixters/Supporting-Antimicrobial-Stewardship-in-Veterinary-Settings_FY24-28_final.pdf&ved=2ahUKewi4lInky9iPAxWQVKQEHQ_qBawQFnoECCgQAQ&usq=A0vVaw2fk24-QbE1gG9e6VPVDzjm)

Franco-Martínez, L., Martínez-Subiela, S., Cerón, J. J., Bernal, L. J., Tecles, F., & Tvarijonavičute, A. (2020). Teaching the basics of the One Health concept to undergraduate veterinary students. *Research in Veterinary Science*, 133, 219–225. <https://doi.org/10.1016/j.rvsc.2020.09.022>

Gabinete de Planeamento, Políticas e Administração Geral. (2020, novembro). *Plano Estratégico da PAC 2021-2027 – Diagnóstico*. [https://www.gpp.pt/images/PEPAC/Draft\\_Diagnostico\\_OE9\\_Novembro\\_2020.pdf](https://www.gpp.pt/images/PEPAC/Draft_Diagnostico_OE9_Novembro_2020.pdf)

García-Sánchez, P., Romero-Trancón, D., Falces-Romero, I., Navarro Carrera, P., Ruiz-Carrascoso, G., Carmona, D., Casares Jiménez, M., Rivero-Juárez, A., Moya, L., Rodón, J., Esperón, F., Pérez-Hernando, B., Sánchez-León, R., Hurtado-Gallego, J., Alcolea, S., Sainz, T., Calvo, C., & Méndez-Echevarría, A. (2024). Zoonosis screening in Spanish immunocompromised children and their pets. *Frontiers in Veterinary Science*, 11. <https://doi.org/10.3389/fvets.2024.1425870>

Gomes, J. C. F. (2021). *A MEDICINA VETERINÁRIA E A RESISTÊNCIA AOS ANTIMICROBIANOS EM CONTEXTO “ONE HEALTH”: A PROPOSTA DE UMA FERRAMENTA DE APOIO À PRESCRIÇÃO DE ANTIMICROBIANOS DE USO VETERINÁRIO* [Universidade Técnica de Lisboa. Faculdade de Medicina Veterinária]. [https://www.repository.utl.pt/bitstream/10400.5/21413/1/A%20Medicina%20Veterin%C3%A1ria%20e%20a%20Resist%C3%Aancia%20aos%20Antimicrobianos%20em%20Contexto%20one%20health\\_a%20proposta%20de%20uma%20ferramenta%20de%20apoio%20%C3%A0%20prescri%C3%A7%C3%A3o%20de%20antimicrobianos%20de%20uso%20veterinario.pdf](https://www.repository.utl.pt/bitstream/10400.5/21413/1/A%20Medicina%20Veterin%C3%A1ria%20e%20a%20Resist%C3%Aancia%20aos%20Antimicrobianos%20em%20Contexto%20one%20health_a%20proposta%20de%20uma%20ferramenta%20de%20apoio%20%C3%A0%20prescri%C3%A7%C3%A3o%20de%20antimicrobianos%20de%20uso%20veterinario.pdf)

Grajeda, L. M. M., John P.; Berger-González, M., López, M. R., Álvarez, D., Méndez, S., Pérez, O., Córdón-Rosales, C., Zinsstag, J. (2021). Sensitivity and representativeness of one-health surveillance for diseases of zoonotic potential at health facilities relative to household visits in rural Guatemala. *One Health*, Volume 13, 100336. <https://doi.org/https://doi.org/10.1016/j.onehlt.2021.100336>

Gruber Kalamas, A. (2004). Anthrax. *Anesthesiology Clinics of North America*, 22(3), 533–540. <https://doi.org/10.1016/j.atc.2004.05.009>

Gyles, C. (2016). One Medicine, One Health, One World. *The Canadian Veterinary Journal*, 57(4), 345–346. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4790223/>

Health For Animals. (2021). *How to Increase Animal Vaccination*. [https://healthforanimals.org/downloads/library/how\\_to\\_increase\\_animal\\_vaccination\\_80\\_recommendations.pdf](https://healthforanimals.org/downloads/library/how_to_increase_animal_vaccination_80_recommendations.pdf)

HealthforAnimalsRoadmap Progress Report 2023 |. (2023, outubro 4). *HealthforAnimals*. <https://healthforanimals.org/reports/roadmap-progress-report-2023/>

Helmholtz HIOH. (2025, March, 03). *One Health Surveillance*. Retrieved 03/03/2025 from <https://www.helmholtz-hioh.de/en/research/teams/team/one-health-surveillance-1/>

Hobbs, B. C., & Roberts, D. (2007). *Food Poisoning and Food Hygiene, 7th edition* (Seventh edition published in 2007 by Hodder Arnold, an imprint of Hodder Education, part of Hachette Livre UK 338 Euston Road, London NW1 3BH). <http://www.hoddereducation.com>

HZI Helmholtz Centre for Infection Research. (2025, March, 03). *HZI Helmholtz Centre for Infection Research*. Retrieved 03/03/2025 from <https://www.helmholtz-hzi.de/en/the-hzi/about-the-hzi/>

Hobbs, B. C., & Roberts, D. (2007). *Food Poisoning and Food Hygiene, 7th edition* (Seventh edition published in 2007 by Hodder Arnold, an imprint of Hodder Education, part of Hachette Livre UK 338 Euston Road, London NW1 3BH). <http://www.hoddereducation.com>

Jánová, E. (2019). Emerging and threatening vector-borne zoonoses in the world and in Europe: A brief update. *Pathogens and Global Health, 113*(2), 49–57. <https://doi.org/10.1080/20477724.2019.1598127>

Jelocnik, M., Ferreira Neto, J. S., & Natale, A. (2025). Editorial: Pathogens at the interface of animals in close contact with humans: risks and benefits, with special regard to immunosuppressed people. *Frontiers in Veterinary Science, 12*, 1560144. <https://doi.org/10.3389/fvets.2025.1560144>

Jornal oficial da União Europeia. (2019, janeiro 7). *REGULAMENTO (UE) 2019/6 DO PARLAMENTO EUROPEU E DO CONSELHO de 11 de dezembro de 2018 relativo aos medicamentos veterinários e que revoga a Diretiva 2001/82/CE*. 4/43-4/167. <https://eur-lex.europa.eu/legal-content/PT/ALL/?uri=CELEX:32019R0006>

Kagira, J. M., & Kanyari, P. W. (2010). Questionnaire survey on urban and peri-urban livestock farming practices and disease control in Kisumu municipality, Kenya. *J S Afr Vet Assoc, 81*(2), 82-86. <https://doi.org/10.4102/jsava.v81i2.110>

Kimani, T., Kiambi, S., Eckford, S., Njuguna, J., Makonnen, Y., Rugulema, G., Morzaria, S., Lubroth, J., & Fasina, F. (2019). *Expanding beyond zoonoses: The benefits of a national One Health coordination mechanism to address antimicrobial resistance and other shared health threats at the human–animal–environment interface in Kenya*. *38*(1), 155. <https://doi.org/10.20506/rst.38.1.2950>

Kisoo, L. A.-L., Yaw; Dias, F., Klett-Tammen, C., Leendertz, F., Zimmermann, F., Lange, B., (2024). Establishing an Epidemic Panel integrating the Human-Animal-Environment Interface for assessing infectious pathogens in Côte d'Ivoire. International One Health Symposium 2024, Mercure Hotel MOA Berlin.

Kumar, A., Bhatt, S., Kumar, A., & Rana, T. (2023). Canine rabies: An epidemiological significance, pathogenesis, diagnosis, prevention, and public health issues. *Comparative Immunology, Microbiology and Infectious Diseases, 97*, 101992. <https://doi.org/10.1016/j.cimid.2023.101992>

- Kyung, S. M., & Yoo, H. S. (2024). Awareness on the spread of carbapenem-resistant Enterobacterales in animals as One Health. *Journal of Veterinary Science*, 25(6), e83. <https://doi.org/10.4142/jvs.24251>
- Listeriosis—Annual Epidemiological Report for 2023*. (2025, junho 5). <https://www.ecdc.europa.eu/en/publications-data/listeriosis-annual-epidemiological-report-2023>
- Liu, C., & Cahill, J. D. (2020). Epidemiology of Rabies and Current US Vaccine Guidelines. *Rhode Island Medical Journal* (2013), 103(6), 51–53.
- Lloyd, D. H., & Page, S. W. (2018). Antimicrobial Stewardship in Veterinary Medicine. *Microbiology Spectrum*, 6(3), 10.1128/microbiolspec.arba-0023–2017. <https://doi.org/10.1128/microbiolspec.arba-0023-2017>
- Manyike, J. Z., Taruvinga, A., & Zhou, L. (2025). Factors influencing livestock ownership and herd intensity among smallholder farmers in the Eastern Cape, South Africa. *Heliyon*, 11(2), e41787. <https://doi.org/10.1016/j.heliyon.2025.e41787>
- McDonnell, G., & Russell, A. D. (1999). Antiseptics and disinfectants: Activity, action, and resistance. *Clinical Microbiology Reviews*, 12(1), 147–179. <https://doi.org/10.1128/CMR.12.1.147>
- McEwen, S. A., & Collignon, P. J. (2018). Antimicrobial Resistance: A One Health Perspective. *Microbiology Spectrum*, 6(2), 10.1128/microbiolspec.arba-0009–2017. <https://doi.org/10.1128/microbiolspec.arba-0009-2017>
- McVey, S., & Shi, J. (2010). Vaccines in Veterinary Medicine: A Brief Review of History and Technology. *The Veterinary Clinics of North America. Small Animal Practice*, 40(3), 381–392. <https://doi.org/10.1016/j.cvsm.2010.02.001>
- Mettenleiter, T. C., Markotter, W., Charron, D. F., Adisasmito, W. B., Almuhairi, S., Behravesh, C. B., Bilivogui, P., Bukachi, S. A., Casas, N., Becerra, N. C., Chaudhary, A., Zanella, J. R. C., Cunningham, A. A., Dar, O., Debnath, N., Dungu, B., Farag, E., Gao, G. F., Hayman, D. T. S., ... Zhou, L. (2023). The One Health High-Level Expert Panel (OHHLEP). *One Health Outlook*, 5(1), 18. <https://doi.org/10.1186/s42522-023-00085-2>
- Moss, B. (2024). Understanding the biology of monkeypox virus to prevent future outbreaks. *Nature Microbiology*, 9(6), 1408–1416. <https://doi.org/10.1038/s41564-024-01690-1>
- Mrzljak, A., Novak, R., Pandak, N., Tabain, I., Franusic, L., Barbic, L., Bogdanic, M., Savic, V., Mikulic, D., Pavicic-Saric, J., Stevanovic, V., & Vilibic-Cavlek, T. (2020). Emerging and neglected zoonoses in transplant population. *World Journal of Transplantation*, 10(3), 47–63. <https://doi.org/10.5500/wjt.v10.i3.47>
- Nana, S. D., Caffin, J.-H., Duboz, R., Antoine-Moussiaux, N., Binot, A., Diagbouga, P. S., Hendriks, P., & Bordier, M. (2022). Towards an integrated surveillance of zoonotic diseases in Burkina Faso: The case of anthrax. *BMC Public Health*, 22(1), 1535. <https://doi.org/10.1186/s12889-022-13878-3>
- National Research Council (US) Committee on Achieving Sustainable Global Capacity for Surveillance and Response to Emerging Diseases of Zoonotic Origin, Keusch, G. T., Pappaioanou,

M., Gonzalez, M. C., Scott, K. A., & Tsai, P. (2009). Drivers of Zoonotic Diseases. Em *Sustaining Global Surveillance and Response to Emerging Zoonotic Diseases*. National Academies Press (US). <https://www.ncbi.nlm.nih.gov/books/NBK215318/>

News, J. (2023, julho 21). *Consulta de Imunomodulação e Risco de Infecção é a que «mais sustentadamente tem crescido»*. Just News. <https://justnews.pt/noticias/consulta-de-imunomodulacao-e-risco-de-infecao-do-s-joao-apoia-colegas-de-varias-especialidades>

Official Journal of the European Communities. (2001, novembro 28). *Directive 2001/82/EC of the European Parliament and of the Council of 6 November 2001 on the Community code relating to veterinary medicinal products*. 311/1-311/66. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32001L0082>

Official Journal of the European Union. (2015, setembro 11). *Guidelines for the prudent use of antimicrobials in veterinary medicine*. 299/7-299/26. <https://bit.ly/2s7LUF2>

Official Journal of the European Union. (2023, junho 22). Council Recommendation on stepping up EU actions to combat antimicrobial resistance in a One Health approach. C 220. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023H0622%2801%29>

One Health Institute, University of California. (2020). *PREDICT Consortium. PREDICT Standard Operating Procedures for One Health Surveillance*. [https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://ohi.vetmed.ucdavis.edu/sites/g/files/dgvnsk5251/files/inline-files/PREDICT%25202%2520SOP%2520Book\\_v3.%2520Aug2020.pdf](https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://ohi.vetmed.ucdavis.edu/sites/g/files/dgvnsk5251/files/inline-files/PREDICT%25202%2520SOP%2520Book_v3.%2520Aug2020.pdf)

Oliveira, B. C. R. da S., Oliveira, J. P., Pinho, A. P. V. B., Dias, R. A., Grisi Filho, J. H. H., Gonçalves, V. S. P., Heinemann, M. B., Amaku, M., Telles, E. O., Ferreira, B. F. S., Ferreira, F., & Ferreira Neto, J. S. (2024). Epidemiological situation of bovine and bubaline tuberculosis in the state of Pará, Amazon region of Brazil. *Frontiers in Veterinary Science*, *11*, 1466199. <https://doi.org/10.3389/fvets.2024.1466199>

One Health Commission. (2024, maio 9). *One Health Education Resources*. [https://www.onehealthcommission.org/en/resources\\_\\_services/one\\_health\\_education\\_resources/](https://www.onehealthcommission.org/en/resources__services/one_health_education_resources/)

One Health High-Level Expert, P., Hayman, D. T. S., Adisasmito, W. B., Almuhairi, S., Behraves, C. B., Bilivogui, P., Bukachi, S. A., Casas, N., Becerra, N. C., Charron, D. F., Chaudhary, A., Ciacci Zanella, J. R., Cunningham, A. A., Dar, O., Debnath, N., Dungu, B., Farag, E., Gao, G. F., Khaitsa, M., . . . Koopmans, M. (2023). Developing One Health surveillance systems. *One Health*, *17*, 100617. <https://doi.org/10.1016/j.onehlt.2023.100617>

O'Neill, J. (2014). *Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations*. [https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations\\_1.pdf](https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf)

Osoro, E. M., Munyua, P., Omulo, S., Ogola, E., Ade, F., Mbatha, P., Mbabu, M., Ng'ang'a, Z., Kairu, S., Maritim, M., Thumbi, S. M., Bitek, A., Gaichugi, S., Rubin, C., Njenga, K., & Guerra, M. (2015). Strong Association Between Human and Animal Brucella Seropositivity in a Linked Study in Kenya, 2012-2013. *Am J Trop Med Hyg*, *93*(2), 224-231. <https://doi.org/10.4269/ajtmh.15-0113>

- Pearce, S. D., Kelton, D. F., Sargeant, J. M., Winder, C. B., Olea-Popelka, F., & Parmley, E. J. (2024). Qualitative description of One Health perception, educational opportunities, and goals of students in programs related to human, animal, and environmental health. *CABI One Health*, cabionehealth.2024.0016. <https://doi.org/10.1079/cabionehealth.2024.0016>
- Pettan-Brewer, C., Martins, A. F., Abreu, D. P. B. de, Brandão, A. P. D., Barbosa, D. S., Figueroa, D. P., Cediél, N., Kahn, L. H., Brandespim, D. F., Velásquez, J. C. C., Carvalho, A. A. B., Takayanagui, A. M. M., Galhardo, J. A., Maia-Filho, L. F. A., Pimpão, C. T., Vicente, C. R., & Biondo, A. W. (2021). From the Approach to the Concept: One Health in Latin America-Experiences and Perspectives in Brazil, Chile, and Colombia. *Frontiers in Public Health*, 9. <https://doi.org/10.3389/fpubh.2021.687110>
- Phillips, H. (2020, março 18). Hand Hygiene. *Australian College of Veterinary Nursing*. <https://vetnurse.com.au/2020/03/18/hand-hygiene/>
- Piorunek, M., Brajer-Luftmann, B., & Walkowiak, J. (2023). Pasteurella Multocida Infection in Humans. *Pathogens*, 12(10), Artigo 10. <https://doi.org/10.3390/pathogens12101210>
- Plowright, R. K., Parrish, C. R., McCallum, H., Hudson, P. J., Ko, A. I., Graham, A. L., & Lloyd-Smith, J. O. (2017). Pathways to zoonotic spillover. *Nature Reviews Microbiology*, 15(8), 502–510. <https://doi.org/10.1038/nrmicro.2017.45>
- Potter, R. F., D’Souza, A. W., & Dantas, G. (2016). The rapid spread of carbapenem-resistant Enterobacteriaceae. *Drug Resistance Updates*, 29, 30–46. <https://doi.org/10.1016/j.drug.2016.09.002>
- Promoting the science of One Health. (2023). *Nature Communications*, 14(1), 4735. <https://doi.org/10.1038/s41467-023-40293-y>
- RHoMIS. (2025, February, 04). *Rural Household Multi-Indicator Survey*. <https://www.rhomis.org/survey.html>
- Rutala, W. A., Boyce, J. M., & Weber, D. J. (2023). Disinfection, sterilization and antisepsis: An overview. *American Journal of Infection Control*, 51(11), A3–A12. <https://doi.org/10.1016/j.ajic.2023.01.001>
- Sørensen, T. M. (2021). Improving hand hygiene standards in the veterinary setting. *Veterinary Record*, 189(1), 29–31. <https://doi.org/10.1002/vetr.702>
- Sandle, T. (2019). Chapter 17—Assessing, Controlling, and Removing Contamination Risks From the Process. Em T. Sandle (Ed.), *Biocontamination Control for Pharmaceuticals and Healthcare* (pp. 287–314). Academic Press. <https://doi.org/10.1016/B978-0-12-814911-9.00017-1>
- Sangwan, N., Gangwal, A., Jain, P., Langtso, C., Srivastava, S., Dhawan, U., Baweja, R., & Singh, Y. (2025). Anthrax: Transmission, Pathogenesis, Prevention and Treatment. *Toxins*, 17(2), Artigo 2. <https://doi.org/10.3390/toxins17020056>
- Schinkel, M., Bousema, T., & van Rij, R. P. (2024). Tripartite interactions between viruses, parasites, and mosquitoes. *Current Opinion in Insect Science*, 64, 101222. <https://doi.org/10.1016/j.cois.2024.101222>

- Selamat, J., & Iqbal, S. Z. (2016). *Food Safety; Basic Concepts, Recent Issues, and Future Challenges*. DOI 10.1007/978-3-319-39253-0
- Setia, M. S. (2016). Methodology Series Module 1: Cohort Studies. *Indian Journal of Dermatology*, 61(1), 21. <https://doi.org/10.4103/0019-5154.174011>
- Shaheen, M. N. F. (2022). The concept of one health applied to the problem of zoonotic diseases. *Reviews in Medical Virology*, 32(4), e2326. <https://doi.org/https://doi.org/10.1002/rmv.2326>
- Steinmann, P., Bonfoh, B., Malick, T., Fané, A., Schelling, E., Niang, M., & Zinsstag, J. (2006). Brucellosis seroprevalence and risk factors for seroconversion among febrile attendants of urban health care facilities in Mali. *Revue Africaine de Santé et de Productions Animales*, 4, 117-121.
- Tambuwal, F. M., Shittu, A., Abubakar, M. B., Salihu, M. D., Junaidu, A. U., Magaji, A. A., Lawal, M., & Danyaro, M. (2009). A survey of veterinary hospitals in Nigeria for the presence of some bacterial organisms of nosocomial and zoonotic potential. *Veterinaria Italiana*, 45(2), 235–241.
- The Ideal Project. (2025, Febraury, 03). *Infectious Diseases of East to African Livestock*. <http://data.ctlgh.org/ideal/>
- Tialla, D., Koné, P., Kadja, M. C., Kamga-Waladjo, A., Dieng, C. B., Ndoye, N., Kouame, K. G., Bakou, S., & Akakpo, A. J. (2015). Prévalence de la brucellose bovine et comportements à risque associés à cette zoonose dans la zone périurbaine de Dakar au Sénégal. *Revue d'élevage Et De médecine vétérinaire Des Pays Tropicaux*, 67(2), 67–72. <https://doi.org/https://doi.org/10.19182/remvt.10186>
- Traore, S., Yapi, R. B., Coulibaly, K., Mathew, C., Fokou, G., Kazwala, R. R., Bonfoh, B., & Alambedji, R. B. (2021). Seroprevalence of brucellosis in small ruminants and related risk behaviours among humans in different husbandry systems in Mali. *PLoS One*, 16(1), e0245283. <https://doi.org/10.1371/journal.pone.0245283>
- Tripartite and UNEP support OHHLEP's definition of «One Health». (2021). <https://www.who.int/news/item/01-12-2021-tripartite-and-unep-support-ohhlep-s-definition-of-one-health>
- Tyski, S., Bocian, E., & Laudy, A. E. (2022). Application of normative documents for determination of biocidal activity of disinfectants and antiseptics dedicated to the medical area: A narrative review. *Journal of Hospital Infection*, 125, 75–91. <https://doi.org/10.1016/j.jhin.2022.03.016>
- US EPA, O. (2015, setembro 28). *Selected EPA-Registered Disinfectants* [Collections and Lists]. <https://www.epa.gov/pesticide-registration/selected-epa-registered-disinfectants>
- van Duin, D., & and Doi, Y. (2017). The global epidemiology of carbapenemase-producing Enterobacteriaceae. *Virulence*, 8(4), 460–469. <https://doi.org/10.1080/21505594.2016.1222343>
- Vector-borne diseases | EFSA. (2023, dezembro 6). <https://www.efsa.europa.eu/en/topics/topic/vector-borne-diseases>

*Veterinary good pharmacovigilance practices (VGVP)* | European Medicines Agency (EMA). (2009, dezembro 31). <https://www.ema.europa.eu/en/veterinary-regulatory-overview/post-authorisation-veterinary-medicines/pharmacovigilance-veterinary-medicines/veterinary-good-pharmacovigilance-practices-vgvp>

Vétérinaires Sans Frontières. (2025, February, 03). *DR Congo: an unprecedented One Health project in the heart of an area at risk from new, emerging pandemics*. <https://vsf-belgium.org/news/dr-congo-an-unprecedented-one-health-project-in-the-heart-of-an-area-at-risk-from-new-emerging-pandemics/>

Weese, J. S. (2004). Barrier precautions, isolation protocols, and personal hygiene in veterinary hospitals. *Veterinary Clinics of North America: Equine Practice*, 20(3), 543–559. <https://doi.org/10.1016/j.cveq.2004.07.006>

WHO. (2009). *Your 5 moments for hand hygiene*. Retrieved 28/02/2025 from [https://cdn.who.int/media/docs/default-source/integrated-health-services-\(ihs\)/infection-prevention-and-control/your-5-moments-for-hand-hygiene-poster.pdf](https://cdn.who.int/media/docs/default-source/integrated-health-services-(ihs)/infection-prevention-and-control/your-5-moments-for-hand-hygiene-poster.pdf)

WHO. (2023). *Antimicrobial resistance*. <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>

WHO. (2024, setembro 26). *Vector-borne diseases*. <https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases>

WHO. (2025). *Prioritizing diseases for research and development in emergency contexts*. <https://www.who.int/activities/prioritizing-diseases-for-research-and-development-in-emergency-contexts>

WHO, FAO, WOA, & UNEP. (2022). *Strategic framework for collaboration on antimicrobial resistance – together for One Health*. (Geneva: World Health Organization, Food and Agriculture Organization of the United Nations and World Organization for Animal Health). <https://openknowledge.fao.org/items/c39f993a-39d6-433a-9dd3-d9849c86a1ea>

WHO, FAO, UNEP, & WOA. (2023). *Implementing the global action plan on antimicrobial resistance: First quadripartite biennial report*. World Health Organization, Food and Agriculture Organization of the United Nations, United Nations Environment Programme and World Organisation for Animal Health. <https://creativecommons.org/licenses/by-nc-sa/3.0/igo/>

Wilkes, M. S., Conrad, P. A., & Winer, J. N. (2019). One Health–One Education: Medical and Veterinary Inter-Professional Training. *Journal of Veterinary Medical Education*, 46(1), 14–20. <https://doi.org/10.3138/jvme.1116-171r>

Willemsen, A., Cobbold, R., Gibson, J., Wilks, K., Lawler, S., & Reid, S. (2019). Infection control practices employed within small animal veterinary practices—A systematic review. *Zoonoses and Public Health*, 66(5), 439–457. <https://doi.org/10.1111/zph.12589>

Winkler, A. S., Brux, C. M., Carabin, H., Neves, C. G. das, Häslér, B., Zinsstag, J., Fèvre, E. M., Okello, A., Laing, G., Harrison, W. E., Pöntinen, A. K., Huber, A., Ruckert, A., Natterson-Horowitz, B., Abela, B., Aenishaenslin, C., Heymann, D. L., Rødland, E. K., Berthe, F. C. J., ...

Amuasi, J. H. (2025). The Lancet One Health Commission: Harnessing our interconnectedness for equitable, sustainable, and healthy socioecological systems. *The Lancet*, 406(10502), 501–570. [https://doi.org/10.1016/S0140-6736\(25\)00627-0](https://doi.org/10.1016/S0140-6736(25)00627-0)

WOAH. (2016). *Strategy on Antimicrobial Resistance and the Prudent Use of Antimicrobials*. [https://www.woah.org/en/document/en\\_oie-amrstrategy/](https://www.woah.org/en/document/en_oie-amrstrategy/)

WOAH. (2025a). Anthrax. *WOAH - World Organisation for Animal Health*. <https://www.woah.org/en/disease/anthrax/>

WOAH. (2025b). Rabies. *WOAH - World Organisation for Animal Health*. <https://www.woah.org/en/disease/rabies/>

World Bank. (2012). *Collecting Livestock Data: A snapshot of survey methods*. <http://hdl.handle.net/10986/17880>

World Health Organization. (2022). *Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report 2022* (CC BY-NC-SA 3.0 IGO). World Health Organization. <https://www.who.int/publications/i/item/9789240062702>

WSAVA. (2023). *Six moments of veterinary antimicrobial prescribing*. [https://150826095.v2.pressablecdn.com/wp-content/uploads/2023/01/WSAVA\\_6MOMENTS\\_Infographic.png](https://150826095.v2.pressablecdn.com/wp-content/uploads/2023/01/WSAVA_6MOMENTS_Infographic.png)