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Implementation of One Health surveillance systems: Opportunities and challenges - lessons learned from the OH-EpiCap application

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ABSTRACT

As the complexity of health systems has increased over time, there is an urgent need for developing multi-sectoral and multi-disciplinary collaborations within the domain of One Health (OH). Despite the efforts to promote collaboration in health surveillance and overcome professional silos, implementing OH surveillance systems in practice remains challenging for multiple reasons. In this study, we describe the lessons learned from the evaluation of OH surveillance using OH-EpiCap (an online evaluation tool for One Health epidemiological surveillance capacities and capabilities), the challenges identified with the implementation of OH surveillance, and the main barriers that contribute to its sub-optimal functioning, as well as possible solutions to address them. We conducted eleven case studies targeting the multi-sectoral surveillance systems for antimicrobial resistance in Portugal and France, *Salmonella* in France, Germany, and the Netherlands, *Listeria* in The Netherlands, Finland and Norway, *Campylobacter* in Norway and Sweden, and psittacosis in Denmark. These evaluations facilitated the identification of common strengths and weaknesses, focusing on the organization and functioning of existing collaborations and their impacts on the surveillance system. Lack of operational and shared leadership, adherence to FAIR data principles, sharing of techniques, and harmonized indicators led to poor organization and sub-optimal functioning of OH surveillance systems. In the majority of studied systems, the effectiveness, operational costs, behavioral changes, and population health outcomes brought by the OH surveillance over traditional surveillance (i.e. compartmentalized into sectors) have not been evaluated. To this end, the establishment of a formal governance body with representatives from each sector could assist in overcoming long-standing barriers. Moreover, demonstrating the impacts of OH-ness of surveillance may facilitate the implementation of OH surveillance systems.

1. Introduction

Recent disease emergences (Ebola, Zika, avian influenza, Covid-19) have reinforced global attention to the importance of integrated infectious disease surveillance systems and the application of the One Health (OH) approach at all levels [1–3]. The approach mobilizes multiple sectors and disciplines, and ensures communication, collaboration, and coordination among all relevant ministries, agencies, stakeholders, sectors, and disciplines, for optimal action [4]. OH surveillance is a collaborative and systematic collection, validation, analysis, interpretation of data, and dissemination of information collected on humans, animals, and the environment to inform decisions for more effective health interventions [5,6]. In practice, different countries have implemented the principle of OH surveillance with varying successes and challenges [7].

While there has been a wide-ranging commitment to the OH approach for addressing complex health problems by several national and international organizations and professional bodies, its operationalization has so far proved to be challenging [8]. Implementation is often a complex issue requiring collaboration between diverse and multi-disciplinary partnerships [1] and mostly occurs in crisis times [8]. For instance, most countries lack formal mechanisms for the coordination and integration of activities across the human and animal health, food safety, and environmental sectors, which are traditionally based in

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separate ministries or government agencies with different mandates on activities and spending. As a result, practical applications of OH approaches have largely been ad-hoc [8,9].

There is a need for regular evaluation of the performance of OH surveillance to identify the main challenges to the effective implementation of OH surveillance [10,11]. In this regard, we developed a generic OH surveillance evaluation tool, OH-EpiCap [12], to characterize and assess epidemiological surveillance capacities and capabilities in existing national surveillance systems. This tool is a standalone, user-friendly, web application developed to conduct an evaluation of multiple aspects related to the organization of the OH surveillance system, its functioning, and its impacts on the surveillance and beyond [12–14]. It supports the diagnosis of strengths and weaknesses in multi-sectoral collaborations and helps to improve collaborative activities at all steps of surveillance [15]. In this study, we assessed the OH practices of foodborne and other zoonotic hazards surveillance systems in several European countries to identify the main barriers that contribute to sub-optimal OH functioning. We have incorporated the findings of eleven surveillance evaluations, including eight previously featured in our earlier publication [12], along with three additional evaluations introduced for the first time in this paper. Although the data from the eight previously showcased surveillance evaluations utilized in both publications were collected concurrently, we have taken deliberate measures to ensure that each paper presents distinct sets of information.

2. Methodology

2.1. Study design

Eleven national multi-sectoral surveillance systems were evaluated using the OH-EpiCap tool between April and November 2022. These surveillance systems focus on foodborne and other emerging zoonotic hazards in European countries: antimicrobial resistance (AMR) in France and Portugal, *Salmonella* in Germany, France and The Netherlands, *Listeria* in Finland, Norway and The Netherlands, *Campylobacter* in Norway and Sweden, and psittacosis in Denmark. These case studies were identified in the framework of the OH European Joint Programme MATRIX project.

The OH-EpiCap tool [12] is a semi-quantitative evaluation tool, organized around three dimensions, each of them divided into four targets (Fig. 1). A full description of the design and operation of the tool is presented in our previous method paper [12]. The first dimension relates to the organization of the OH surveillance system, including the formalization of the system, coverage, availability of resources, and evaluation. The second dimension assesses operational activities such as data collection and methods sharing, data sharing, data analysis and interpretation, and communication. The last dimension evaluates the impacts of the OH surveillance system and comprises targets for technical outputs, collaborative added-value, immediate and intermediate outcomes, and ultimate outcomes. Each target score is calculated from four indicators. A standardized scoring guide details, for each indicator, the possible scores and how they should be awarded [16].

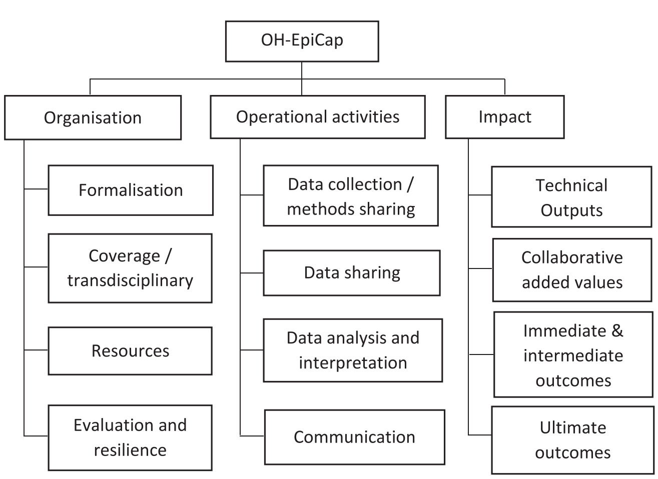

Fig. 1. Structural overview of the OH-EpiCap targets, grouped by dimension (from [12]).

OH-EpiCap evaluation of a surveillance system takes place through a half-day workshop gathering a panel of surveillance representatives from the sectors and disciplines relevant to the hazard of interest. For each question in the questionnaire, the panel jointly agrees on the answer that best represents their system between four options, which is then transformed into a semi-quantitative scale ranging from 1 to 4. Score 1 reflects poor performance to OH principles, signaling a need for significant improvement. Score 2 suggests below-average performance with room for enhancement. Score 3 indicates satisfactory performance, meeting basic requirements but possibly lacking depth. Score 4 represents outstanding performance, exceeding standards with exceptional quality and possibly innovative approaches. The value “Not Applicable (NA)” can also be used if the indicator is considered as not relevant to the OH surveillance system under evaluation. The OH-EpiCap questionnaire responses are analyzed at the target level, by averaging the scores of the four indicators constituting it to produce a final score ranging from 1 to 4. Similarly, dimension-level averages represent the mean scores across all questions of the dimension. The overall evaluation result is then derived by averaging dimension-level outputs as a percentage. The evaluation is conducted using the OH-EpiCap Shiny application (https://freddietafreeth.shinyapps.io/OH-EpiCap/), which summarizes and visualizes the results in the form of a report with interactive figures. If a workshop cannot be organized, the questionnaire can be filled sequentially by the surveillance representatives from each sector, with a back-and-forth process to reach a consensus.

Representatives of the surveillance systems of psittacosis in Denmark, *Listeria* in Finland, *Salmonella* in Germany, and *Campylobacter* in Sweden carried out the evaluation through a half-day workshop. Other evaluations were conducted through the completion of the questionnaire, either sequentially by experts from several sectors of surveillance (e.g. AMR in Portugal, AMR in France, *Campylobacter* in Norway), or by one to two experts who had a good knowledge of the organization of the surveillance and collaborations across sectors (e.g. *Salmonella* in France, *Listeria* and *Salmonella* in the Netherlands, and *Listeria* in Norway). A list of the institutes that participated in each OH-EpiCap evaluation is provided in supplementary file 1. The Results and Discussion section below presents the main weaknesses and strengths identified from the OH-EpiCap scores and the contextual and interpretive comments provided by the evaluators (surveillance representatives).

3. Results and discussion

Our study focused on existing collaborative practices in eleven multi-sectoral surveillance systems targeting foodborne and emerging zoonotic hazards in various European countries (Supplementary material 1). The overall OH-EpiCap scores across the eleven systems evaluated were between 32.4 and 86.1 out of 100.0, with a mean score of 49.0 and a standard deviation of 17.7, indicating a wide spread of results (Fig. 2, green bars). Systems scoring high overall generally had high scores in Dimension 1 (Organization). The classification of the studied systems according to their OH-EpiCap overall score (Fig. 2) showed that systems with a low OH-EpiCap overall score scored roughly the same across all three dimensions. An increase in the OH-EpiCap overall score is generally linked to a high score in Dimension 1 (Organization). In contrast, weaknesses in Dimension 3 (Impact) was observed in the systems with an intermediate OH-EpiCap overall score (around 50.0%). For some of the systems with the highest OH-EpiCap overall score, the weakest dimension was Dimension 2 (Operational activities); however, System 9

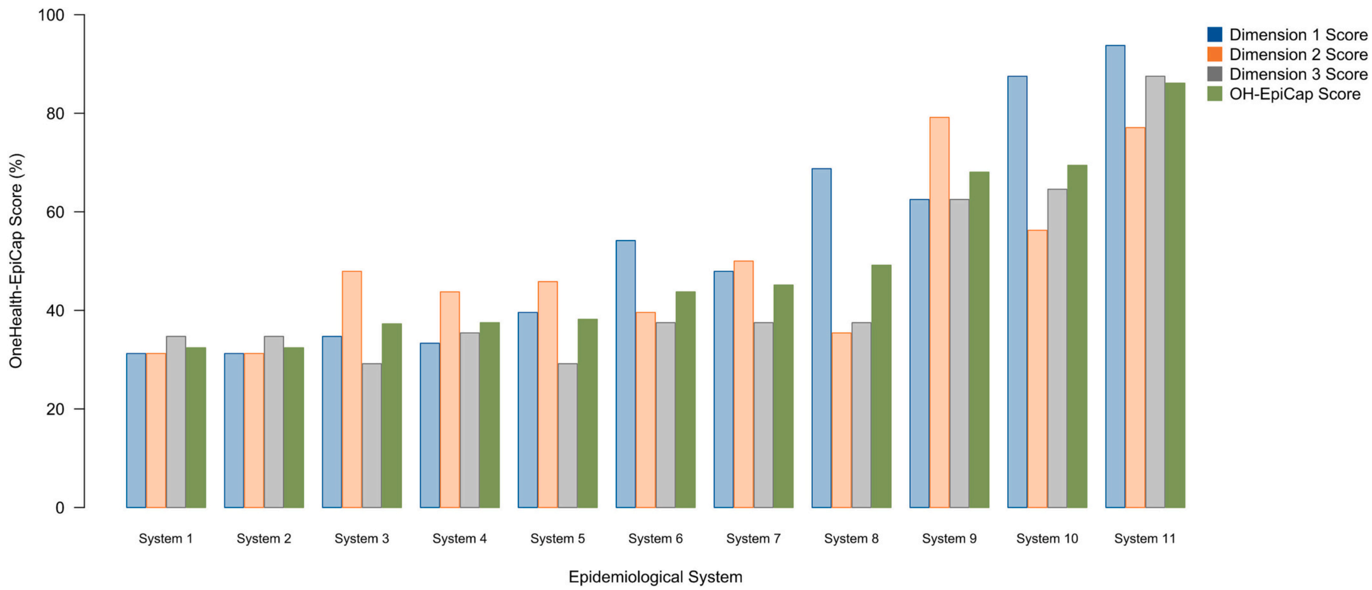

Fig. 2. Dimension-specific (Dimension 1: Organization – blue, dimension 2: Operational activities – orange, and dimension 3: Impact – grey) and overall (green) OH-EpiCap scores for each epidemiological system evaluated. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

did not follow this trend, with Dimension 2 being higher than Dimensions 1 and 3, which scored roughly equally.

Overall, the median score of the targets across the systems evaluated were between 2 and 3 (Fig. 3). A narrow interquartile range (e.g. for the target *Communication*) indicates that all systems were consistent in performances, while a large interquartile range (e.g. *Data analysis and interpretation*) reflects variability in performances across surveillance systems. The target *Coverage / Transdisciplinary* was the only one with a

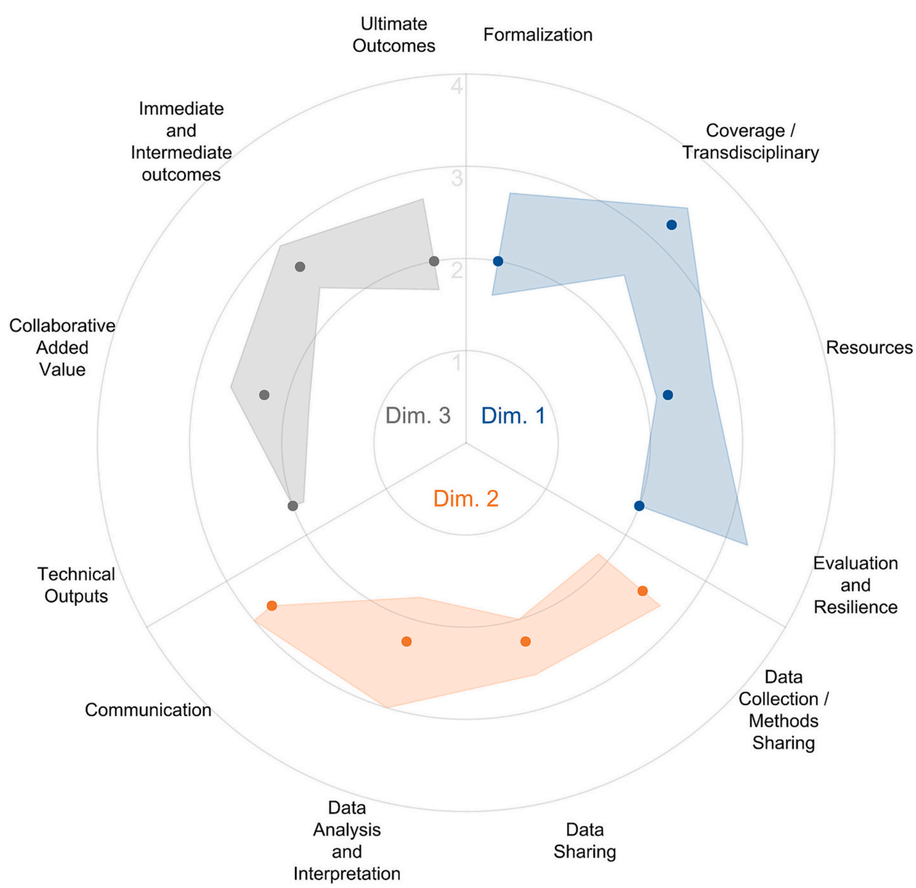

Fig. 3. OH-EpiCap dimensions visualised at the target level. Plotted points indicate the median score with interquartile range indicated by the shaded polygons across all systems investigated. Dim1 – Dimension 1: Organization, Dim2 – Dimension 2: Operational activities and Dim3 – Dimension 3: Impact. The targets included in each Dimension are listed around the margins.

median score exceeding 3. The four targets scoring lower on average were *Formalization*, *Evaluation and Resilience*, *Technical Outputs*, and *Ultimate Outcomes*, each with a median score of 2. OH-EpiCap dimensions visualised at the indicator level are provided in Supplementary material 2. For each indicator, we provide below the median value and interquartile range across the 11 studied systems (when an answer NA was provided by one or more surveillance systems, we specified within parentheses the number of systems that did score the indicator).

3.1. Dimension one - organization

Regarding the target *Formalization*, 7 out of 11 surveillance systems established a cross-sectoral aim (median [interquartile range]: 3 [1.5–3]) through participative approaches or from inter-ministerial documents. However, it is noted that these efforts may not fully align with all stakeholder expectations. Various types of supporting documentation (2 [2–2]) were reported, including legislation, strategy papers, and inter-ministerial commitments. Surveillance representatives specified that supporting documentation is typically shared across sectors and institutions, but also indicated that some information is missing (e.g. objectives of OH, role of actors in steering the surveillance system, modalities of organization and functioning of the collaborations, mechanism for allocation of resources for collaboration) for the proper formalization of OH collaborations. Legislative support is critical for OH formalization, as it provides guidelines for coordinating and integrating surveillance programs across sectors [8,9]. Additionally, there is a lack of operational and shared leadership between sectors (1 [1–3]) and large variability among systems for coordination (2 [1–3]). Previous studies emphasized the importance of establishing a steering committee to manage OH activities and engage decision-makers, ministers, and officials from all sectors [2,3]. Bridging human, animal and environmental health requires multidisciplinary and cross-sectoral leadership. This leadership must address collaboration gaps, minimize duplication, and prevent divisions and isolation [17,18]. A set of recommendations regarding OH governance, considering important elements such as transparency, accountability, and responsibility, was proposed by experts from the OH-EJP COHESIVE project in their guidelines for establishing a OH risk analysis system for zoonoses [19].

In terms of *Coverage and transdisciplinarity*, the evaluated surveillance systems encompassed the majority of relevant sectors (3 [3–4]) and disciplines (3 [3–3]), yet often neglected the environmental sector. Previous studies also mentioned that although OH should rely on the triad of human, animal, and environmental health, the last mentioned is often overlooked [20–22]. More specifically, the wildlife component and related ecological issues such as community ecology, evolutionary ecophysiology, and environmental science (soil and climate) were neglected [23,24]. In recent years, several efforts have been made to engage the environmental sector for collaborative OH action. Thus, in 2022, the United Nations Environment Programme (UNEP) joined the tripartite collaboration as an equal partner to implement OH approach [25]. Moreover, our study also identified a limited representation of economics and social science in the evaluated surveillance systems (with no representative of these two disciplines in the panels). Similarly, previous research has highlighted the marginalization of social, legal, and economic sciences within OH [23,26]. Yet, economics and social sciences have recently gained recognition as essential pillars for developing sustainable strategies against zoonotic diseases [10,26]. Besides, results regarding the coverage of actors underlined some variability between studied systems (3 [2.5–4]): three systems reported that only few types of actors relevant to the hazard under surveillance were included, whereas more than half or all relevant types were included in other systems. Implementation of OH surveillance requires integration of various public, private, political, civil society, and business sectors [2]. Identifying and early engaging all actors involved in surveillance can help build trust and create a conducive environment for acceptable and sustainable collaborative solutions [27,28]. Mapping of the surveillance programs and stakeholders is therefore recommended to identify their roles and missions and characterize the interactions between them [27–30]. Geographical coverage and inclusion of less represented populations varied between evaluated systems (3 [2–4]). Yet, the reinforcement of links with surveillance systems focusing on similar hazards (e.g. mosquito-borne diseases, abortive cattle diseases) has been shown to increase surveillance capacities through the sharing and joint analysis of data, favouring preparedness and rapid mitigation response [31].

Regarding *Resources*, 5 out of 11 systems reported that there was no budget or a budget considered as neither sufficient nor sustainable for the OH surveillance system (3 [2–3]). Human resources (2 [2–2.5]) were also described as below average in 8 out of 11 systems. In contrast, existing resources (materials, equipment, etc.) are usually shared between sectors (3 [2.5–3]). Our results also showed the existence of OH-focused training opportunities (2 [1.5–3.5]), although they remain insufficient and not specific to the surveillance of the hazard of interest. Organizing joint communication training or pre-emptive collaborative training (such as outbreak simulation exercises) [32] and reinforcing OH education are important to foster multi-sectoral collaborations [3,19,33]. OH training should also include cross-cultural communication skills, team building and trust development [18].

Regarding *Evaluation*, internal evaluations are rarely carried out or only partially (2 [1–3]). Similarly, only some systems conducted external evaluations (2 [1–3], $n = 10$) through national authorities or international health agencies like EFSA and ECDC. Some evaluation-based corrective measures were implemented (2.5 [2–3], $n = 6$), underlying the interest of those evaluations. The OH-EpiCap evaluation framework [12] provides a standalone tool for surveillance representatives to conduct an internal evaluation in a short time (half-day workshop). A more thorough evaluation of the weaker OH aspects can then be considered using evaluation tools dedicated to the functioning and performance of surveillance [34] and/or OH aspects [35]. Moreover, the OH-LabCap tool (https://onehealthejp.eu/jip-ohharmony-cap/) supports the assessment of OH capacities related to laboratory activities. Regarding the adaptability to changes (3.5 [3–4], $n = 10$), the studied systems indicated their ability to adapt to changes in the OH surveillance system coverage or organization, and most of them (8/10) were also able to adapt to innovation and new activities and even to a critical situation in a short time (5/10).

3.2. Dimension two - operational activities

Regarding *Data collection and methods sharing*, studied systems showed diversity in the level of cross-sectoral collaborations for protocol design (3[1.5–3]), data collection (2 [1.5–3]) and lab techniques (3 [1.5–3]). In few evaluated systems (4/11), joint data warehouses were set up between sectors (2 [2–3]), in particular for sequencing or notification data. These are accessible to relevant stakeholders to upload or download data, or only to access data. Examples of joint aggregated surveillance databases are presented in the literature [42–44].

Regarding *Data sharing,* our study revealed a lack of adherence to FAIR data principles in 8 out of 11 evaluated systems (2 [1–2.5]). Additionally, we observed diversity in the implementation of data sharing agreement (specifying issues related to data management, storage, ownership and confidentiality) between relevant sectors (2 [1–3]). Despite the recognized importance of FAIR data, practical application remains challenging [36–38]. Numerous obstacles, including ethical, organizational, legal, technical, political, and economic issues, hindered timely and effective data sharing between health authorities and stakeholders [2,19,38,39]. Common best practices for data collection, sharing, analysis, interpretation, and dissemination were reviewed in recent studies [19,29]. Additionally, our study found that data quality evaluation (2 [2–3]) was not systematically conducted. EFSA underlined the importance of enhancing data quality and interoperability to better leverage existing data for risk assessment and preparedness within the OH framework [40]. In the evaluated systems, data quality evaluation approaches included proficiency tests, ISO/IEC 17025 accreditation, or dedicated tools. These approaches facilitate data monitoring and communication with providers and stakeholders [41]. An important point for that target is that in 8 out of 11 studied systems data is shared between relevant (if not all) sectors and serves its purpose in the context of OH surveillance (3 [2.5–3]).

Regarding *Data analysis and interpretation,* our study showed limited technique sharing (1.5 [1–2], $n = 10$), and the use of few or no harmonized indicators (2 [1–3]) across sectors. Some of the evaluated systems (5/11) reported joint analysis of data from multiple sectors (2 [2–3]) or joint interpretation of results from several sector-specific analyses (through sharing of expertise) (3 [2–3.5]), mostly during outbreak investigations or in collaborative projects. Accordingly, such joint analyses of data favour preparedness and rapid mitigation response [31]. Moreover, combining data from different syndromic surveillance components showed promise for improving the surveillance of foodborne disease outbreaks in humans [45].

In terms of *Communication*, most of the evaluated systems reported that internal communication was established across some sectors (3 [2–3]) but could be improved, in particular through the implementation of a formal system. Inter-disciplinary and OH glossaries help overcome communication hurdles (due to sector-specific terminology) and harmonize information exchange between sectors [19,46,47]. Yet, in the event of a suspected or detected case (i.e. emergence) (3 [3–3]), the information shared enables other sectors to take appropriate preventive, surveillance or control measures, even if transmission delays could be further reduced. Joint external communication appears well developed (3 [3–3.5]), while information dissemination to decision-makers occurs mostly within sectors (2 [2–3]). The development of operational dashboards can facilitate the sharing of raw data and sensitive information internally and to decision makers through password restricted access, and the display of aggregated and digested information to the large public, using an open access [48].

3.3. Dimension three - impact

Regarding *Technical Outputs*, our evaluations revealed that, in the majority of instances (8/10), the effectiveness (1 [1–1], $n = 10$) of OH surveillance (over traditional approaches, monitoring human, animal, and environmental health separately with limited intersectoral collaboration) and its associated operational costs (1 [1–1], $n = 9$) have not been formally assessed using comprehensive methods. While OH surveillance has been in place for over a decade with the expectation of improving efficiency by reducing overlaps among sectors, systematic evaluation of key attributes still remains limited [18,39,49]. Surveillance representatives also mentioned that although large outbreaks are often detected in real-time (3 [2–3]), retrospective analyses using WGS data revealed undetected emergencies in some sectors. Overall, we found that the OH approach has enhanced surveillance effectiveness by detecting more outbreak sources and providing insights into the genetic diversity and clustering of foodborne hazard isolates from different sectors, particularly through WGS data sharing. It has also improved the knowledge of the epidemiological situation (3 [3–3.5]). However, the costs of OH surveillance were found to be increased due to integrated molecular surveillance, additional personnel time with the arrival of WGS analysis, and epidemiological investigations in case of links between human cases and production facilities. Despite being resource-intensive, joint surveillance efforts have also shown economic benefits [39]. Some studies proposed outcome metrics and methodological frameworks for evaluating OH interventions [49–51].

Regarding *Collaborative added value*, although official OH teams (3 [1.5–3]) or networks (2 [1–3.5]) are not well established, collaboration and trust among different sectors have grown through OH surveillance activities. Challenges to foster multidisciplinary collaboration and build operational OH networks are detailed by Khan et al. [21]. We found that international collaborations for hazard surveillance remain sector-dependent (2 [2–3]), relying on specific networks and international health agencies: EFSA and ECDC for the animal and human sectors, and the European Environment Agency (EEA), European Chemicals Agency (ECHA), and EU Commission for the environmental sector. For AMR, effective international collaboration occurs through the Joint Inter-Agency Antimicrobial Consumption and Resistance Analysis (JIACRA), involving the human and animal sectors [40] and global action plans encompassing human, animal, and environmental sectors [52]. Common strategic plans for other hazards are in progress (1 [1–4]), with guidance provided by the quadripartite OH Joint Plan of Action [25] and the Generalizable OH Framework, which compiles resources for OH development from local to international levels [28].

Regarding *Immediate and intermediate outcomes,* surveillance representatives indicated that multi-sectoral preparedness and response capacity are in place but emphasized the need for faster and more sensitive responses (3 [3–4], $n = 10$). One system mentioned its will to build on previous experiences to elaborate procedures regarding multisectorial and multi-actor investigations. OH surveillance was also found to provide quality evidence for intervention measures but rarely in a timely manner (2 [1.25–3], n = 10). One example regarding AMR surveillance was the voluntary ban of third- and fourth-generation cephalosporins by the pig/poultry industry, which came out of integrated analysis of human and animal surveillance data. Other systems however underlined a lack of epidemiological data to complete information collected during outbreak investigations to elaborate evidence-based intervention measures. Advocacy efforts were implemented to influence public policy, laws and to educate target groups (government officials, students in health education, and the public) about the mitigation of hazard risk based on information from the OH surveillance (3 [2.25–3.75]). However, its contribution to increasing awareness and understanding of hazards remained limited for some stakeholders (2 [2–3], $n = 10$). Conducting Knowledge, Attitude, and Practices surveys can help identify this contribution [53].

In terms of Ultimate outcomes, OH surveillance led to some policy changes in five studied systems (2.5 [1.25–3], n = 10), such as updating shelf life for risk products and revising antimicrobial use policies in veterinary medicine and humans. With the exception of one system, OH surveillance creates opportunities to develop and conduct collaborative research across sectors (3 [3–3], $n = 10$). Indeed, research programs based on multi-institutional consortia, involving multiple disciplines, enable the application of holistic and integrated approaches to tackle the complexity of questions at the interface between human, animal and environmental health. At last, impacts of OH surveillance on behavioral changes (1.5 [1–3], $n = 8$) and health outcomes (1 [1–2.75], n = 10) varied widely among studied surveillance systems. Besides, even when education of the general population and target groups around food and health showed some changes in practices regarding the consumption of *Listeria* or *Salmonella* risk food, these foodborne pathogens continue to represent an important threat for health.

4. Conclusion

Although this sample of surveillance systems is not representative of the diversity of situations in OH surveillance, it provides a large overview of strengths and weaknesses regarding multiple aspects (organization, operational activities, and impact) of OH. The power of OH-EpiCap evaluations relies on the free sharing and exchange of points of view and perceptions by representatives ideally from all sectors and disciplines involved in the surveillance. Accordingly, the panels of surveillance representatives who conducted the evaluations were selected to cover all relevant sectors for the hazard under surveillance. Yet, including the environmental sector was not always feasible especially when this sector was not or had little involvement in the integrated system. Additionally, the surveillance representatives may have different expectations and various levels of knowledge about the surveillance system. However, biases and subjectivity in the scoring is limited by the use of a standardized scoring scale and by the fact that the panel needs to reach consensus to answer each indicator.

There are instances where several sectors may not be immediately available to conduct the OH-EpiCap evaluation (which occurred for some evaluations in our study). In such cases, the initiation of tool usage by a single sector becomes a practical approach. This flexibility allows for the adaptive use of the tool, addressing the challenges associated with limited sectoral participation. Having a limited number of representatives may introduce the possibility of subjectivity into the evaluation process. Yet, the communication of the OH-EpiCap results to all sectors (using the report generated by the application) may facilitate the identification of points of divergence. It is crucial to engage in a more extensive discussion involving representatives from various disciplines and sectors to ensure the reliability and comprehensiveness of the evaluation outcomes. This insight is essential for refining the evaluation process and securing robust and unbiased results.

Using a scoring scale with only four levels makes the tool easy to use by surveillance representatives to describe the level of compliance of the examined system with respect to an ideal situation. It provides a macro-level analysis of overall organization, functioning and impact of multi-sectoral collaborations and facilitates the identification of strengths and weaknesses at different levels. A more in-depth assessment of the functioning and performance of the system can be carried out using specific tools [34,35], which require more time to implement. Besides, the benchmarking module of OH-EpiCap offers the opportunity to compare the studied system to other relevant systems (for example, across countries for the same hazard). Thus, each result of the studied system is compared to the interquartile range of the relevant (target-level or indicator-level) score in the reference dataset. This additional information helps surveillance representatives to identify areas where other systems perform better and, by drawing on their practices, to make their system evolve toward more OH integration.

In summary, our study evaluated various integrated surveillance systems across Europe, offering a comprehensive overview of strengths and areas for improvement in OH functioning. While European laws and standards influence national policies, each country tailors its surveillance and OH regulations to its unique epidemiological situation and ongoing context (technical infrastructure, surveillance capacity, policy support, etc.). Each surveillance system is inherently distinct, and its potential for evolution toward more integration will depend on the expectations of the various actors and their willingness and capacity to further develop and enhance collaborations at all steps of the surveillance. The OH-EpiCap tool is generic and standalone and we therefore encourage surveillance representatives to conduct such an evaluation of their system to identify their best way forward. Furthermore, given the simplicity and limited time required, we recommend conducting such OH-EpiCap evaluations regularly to monitor the evolution of OH practices over time and their impact on health at the human-animal-environment interface.

Author contributions

VH and JP conceptualized the study. HT, JR, LC, and VH conducted the case studies. CB, FF, ET, and JP developed and maintained the web application for data collection and visualization. HT and VH drafted the manuscript, and all authors participated in editing, reviewing, and approving the final version.

Confidentiality and ethical statement

The MATRIX project obtained ethical approval from the advisors of the One Health European Joint Programme. Participants were informed via email and verbally about: 1) The voluntary nature of using the OH-EpiCap tool and application; 2) Compliance of the OH-EpiCap tool with the European General Data Protection Regulation, ensuring no collection of personal information; 3) Non-retention of data related to the evaluated OH surveillance system by the web application.

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Declaration of competing interest

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

Data availability

The R code and anonymised data used to generate the figures in this paper, and the supplementary figures, can be found in the following GitHub repository https://github.com/FreddieTAFreeth/OH-EpiCap-Cross-System-Analysis.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.onehlt.2024.100704.

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