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Systematic review on evaluation tools applicable to One Health surveillance systems: A call for adapted methodology

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ABSTRACT

Developing and implementing effective surveillance programs for infectious diseases (ID) and antimicrobial resistance (AMR) requires the integration of information across relevant disciplines and sectors. Yet, establishing and sustaining collaboration at each step of the surveillance process, and modalities to translate integrated surveillance results into actions, are not well understood. This systematic review was designed to map and explore peer-reviewed tools that were either designed or used for evaluation of integrated surveillance systems for ID or AMR, and to identify the limitations of these tools and remaining methodological or knowledge gaps. A systematic search was conducted using keywords related to: "Evaluation", "Surveillance" and "One Health" in four databases (Medline, Embase, Web of Science and CAB abstract) up to the 28th of October 2022. Articles were selected if they presented an evaluation tool for integrated surveillance systems for ID or AMR (methodological study) or an application of such a tool (case study). All selected articles went through a quality check using the MetaQAT tool. Of 25 articles retrieved, 13 presented a methodological study, while 12 described a case study. Three main types of evaluation were identified through 17 tools: theoretical, process and impact evaluations. Both methodological and case study papers predominantly considered organizational and operational aspects in their evaluation. Although costs and/or impacts were discussed in some case studies, only one article reported an economic impact analysis. Evaluation of One Health integration and multisectoral collaboration was included in four methodological and four case study articles. One major challenge identified in this systematic review is the lack of clear guidance and standardized criteria for the comprehensive evaluation of complex integrated surveillance systems. To overcome this, it is essential to develop, validate, and apply methodologies adapted to these evaluation needs.

1. Introduction

Surveillance is needed to build and maintain human, animal and ecosystem health as it generates the information needed to support decision making and policy regulation at different levels [1–3]. In the context of infectious diseases (ID) and antimicrobial resistance (AMR), the integration and sharing of data across the human, animal and environmental sectors is crucial for effective surveillance [4,5]. Recognizing this, the quadripartite alliance released a One Health (OH) research priority agenda, outlining the need to invest in integrated surveillance [6,7].

Health threats such as AMR and ID can be challenging to monitor as they affect different populations and can spread via many routes of transmission [8]. Reflecting this complexity, national AMR surveillance programs have adopted various approaches to foster integration at different steps of the surveillance process and in their governance structure. For instance, in France, while AMR surveillance is implemented through different programs specific to each sector, the data are regularly gathered and combined into joint human-animal surveillance reports and communications to inform end-users [9]. In contrast,

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countries like Denmark or Canada adopted a more centralized model where human, animal, and marginally, environmental surveillance components for AMR are integrated into a single program [10].

OH integration involves collaborative efforts between at least two sectors (e.g., human health, animal health, plant health, food safety, wildlife and/or environmental health) and at different levels (e.g., governance, management, coordination, implementation) [11]. Aenishaenslin et al. proposed to define OH integrated surveillance as "*the systematic collection, analysis, interpretation of data, and dissemination of information collected from different components of a system to provide a global, multidisciplinary, multiperspective understanding of a health problem and to inform system-based decisions across all relevant sectors*" [12].

The benefits of OH integrated surveillance include the sharing of resources, knowledge and expertise from different disciplines [13–15]. However, the premises of this approach are more ambitious, as it aims to: 1) improve the effectiveness and economic efficiency of disease prevention and control efforts; and 2) develop more resilient and sustainable systems [2,16]. Conventional tools for evaluation of public health and animal health surveillance generally focus on the technical performance of the system (e.g., sensitivity, timeliness) rather than its efficiency [17,18], and very little research is available on the added value of the OH approach in improving the efficiency of surveillance and mitigation strategies [4,19,20]; a gap highlighted by several authors [4,15,21]. Moreover, the applicability of conventional and newer evaluation tools of OH integrated surveillance systems for AMR and ID has never been systematically investigated [22,23]. Therefore, available tools have not been mapped in a comprehensive way, to allow identification of evaluation needs and gaps.

This review was conducted to examine the peer-reviewed literature with the aim of summarizing existing evaluation tools that can be applied to OH integrated surveillance systems for AMR or ID, as well as reviewing studies that have applied such tools, identifying their scope, strengths, and limitations.

2. Methods

This systematic review was conducted following the 2020 updated PRISMA guidelines [24] and the protocol was registered on the PROSPERO platform (**CRD42021221619**). Five main questions guided the review: 1) What are the evaluation tools that are applicable to OH integrated surveillance systems for antimicrobial use (AMU)/ AMR and ID? 2) Which evaluation criteria are included in these tools? 3) Have these evaluation tools considered how the OH approach is integrated into the surveillance system, and if so, how? 4) How have these tools been used to assess existing surveillance systems for ID and AMR? And, finally, 5) What are the limitations of these tools and remaining methodological or knowledge gaps regarding evaluation tools for integrated OH surveillance?

We defined an evaluation tool as a structured approach to the evaluation of one or multiple aspects or components of a program or intervention. Secondly, following Aenishaenslin et al. [12], we defined a surveillance program as "*a planned set of strategies and activities that are organized and interconnected in order to achieve the objectives of surveillance, including its resources, infrastructures, activities, and internal and external factors*". In a broader sense, a surveillance system can in itself encompass one or several surveillance programs [12,15].

2.1. Search strategy

Three concepts were used: "One Health", "Surveillance" and "Evaluation tool". Related keywords and Medical Subject Headings were added, when applicable: ["One health" OR "One medicine" or "Eco health" or Ecohealth or (animal and human) or (veterinary and human) or one health/ or global health/] AND [Surveillance or "Integrated surveillance" or Monitor* or detect* or disease surveillance/] AND [(evaluat* or assess*) adj4 (frame* or tool* or guideline*)]. Adding a concept related to ID and/or AMR to the search equation restricted the results, so we opted to include this element in the inclusion/exclusion criteria instead.

Four different databases were used: Medline, Embase, Web of science and CAB abstracts; and the query was adapted to each. The search was designed to include all relevant records published up until the 28th of October 2022.

The search strategy was discussed within the research team and guided by pilot searches conducted with an experienced librarian at the University of Montréal.

2.2. Eligibility criteria

Studies were eligible if they were original research articles that: 1) presented an evaluation tool applicable to a OH integrated surveillance system for AMR or ID (methodological studies) or 2) evaluated such system (case studies). Papers were excluded when: 1) there was no reference of a surveillance system (case studies) or applicability to a surveillance system (methodological studies); 2) there was no mention of an evaluation process; or 3) there was no OH integration aspect (at least two of the three components of OH: human/animal/environment). Only articles with available full text in English, French, Italian, Spanish, Portuguese, or Arabic were considered. Since the topics of interest were ID and AMR, no restrictions were placed on the populations studied as all subgroups were considered at risk.

Reviews deemed eligible based on the criteria listed above were used as part of a snowballing process by scanning their reference list for relevant articles. Additionally, two expert members of the research team (CA and HC) were consulted to ensure no relevant papers were missed.

2.3. Quality assessment

The meta-tool for quality appraisal of public health evidence (MetaQAT) was used to assess the overall quality of the included studies as well as the risk of bias [25]. MetaQAT is an assessment framework developed for appraising public health evidence. The tool was used to evaluate qualitatively four domains: 1) relevance, 2) reliability, 3) validity and 4) applicability of research studies, through a set of questions related to each [25]. Studies that demonstrated satisfactory quality, based on the responses to these questions, were included in the analysis.

2.4. Screening process

Results from the databases queries were extracted and uploaded into a software for managing and streamlining systematic reviews (covidence.org) [26]. Two independent reviewers (SM, CN) screened the title and abstract of each record. In case of disagreements, a third reviewer (CA or HC) was consulted to resolve the conflict. Articles included after the first screening were read in full and reviewed again by SM and CN. The same eligibility criteria were used during the screening and full text review. Papers collected via snowballing and expert's consultation went through the same screening process.

2.5. Data extraction and analysis

The following information was extracted from each article that was included following full text review: authors, title, publication year, full citation with DOI, keywords, purpose of the study and health sectors included (animal/human/environment). For studies presenting an evaluation tool (methodological studies), we extracted information about the evaluation scope (technical/ economic, etc.), evaluation process (including methods), general and specific evaluation criteria, previous applications if mentioned, as well as limitations. For studies evaluating a surveillance system (case studies), we also extracted information about objective of the evaluation, description of the surveillance system, context details when applicable (e.g., country, period of study) and the evaluation results. Given the scope of this research, we specifically extracted information regarding OH integration, when available [2].

Data extracted from the eligible papers was used to identify evaluation patterns and themes. In addition, evaluation criteria used in each paper were extracted and combined to describe the range of approaches mentioned or applied for the evaluation of OH integrated surveillance systems for AMR and ID. Results of case studies were also categorized into strengths and weaknesses, as well as gaps that need to be addressed.

3. Results

The initial search found 2757 records, of which 788 were identified as duplicates and excluded on the Covidence platform. The title and abstract of the remaining 1969 articles were screened, of which 1888 were excluded, leaving 81 records for full text review. Of these, 60 articles were excluded (Fig. 1), mostly due to no mention of surveillance and/or no evaluation aspect. Four papers were added to the 21 retained records through snowballing and experts' consultation and went through the same process, for a total of 25 papers included. Thirteen articles were classified as methodological and described 11 evaluation tools while 12 articles presented case studies, with four applying one of the 11 tools identified in the methodological papers and eight using different evaluation tools.

Most of the retrieved studies were specific to ID (18/25) from a OH perspective, three focused on AMR [12,13,27–31], while two focused on biosurveillance- i.e. surveillance of all biological hazards or threats to human/ animal or plant health (whether infectious, metabolic, chemical, etc. [32,33], one on population health [34] and one on environmental public health [34,35]. Aspects specific to the evaluation of OH integration were included in four methodological studies and four case studies [12,28,29,31,36–39].

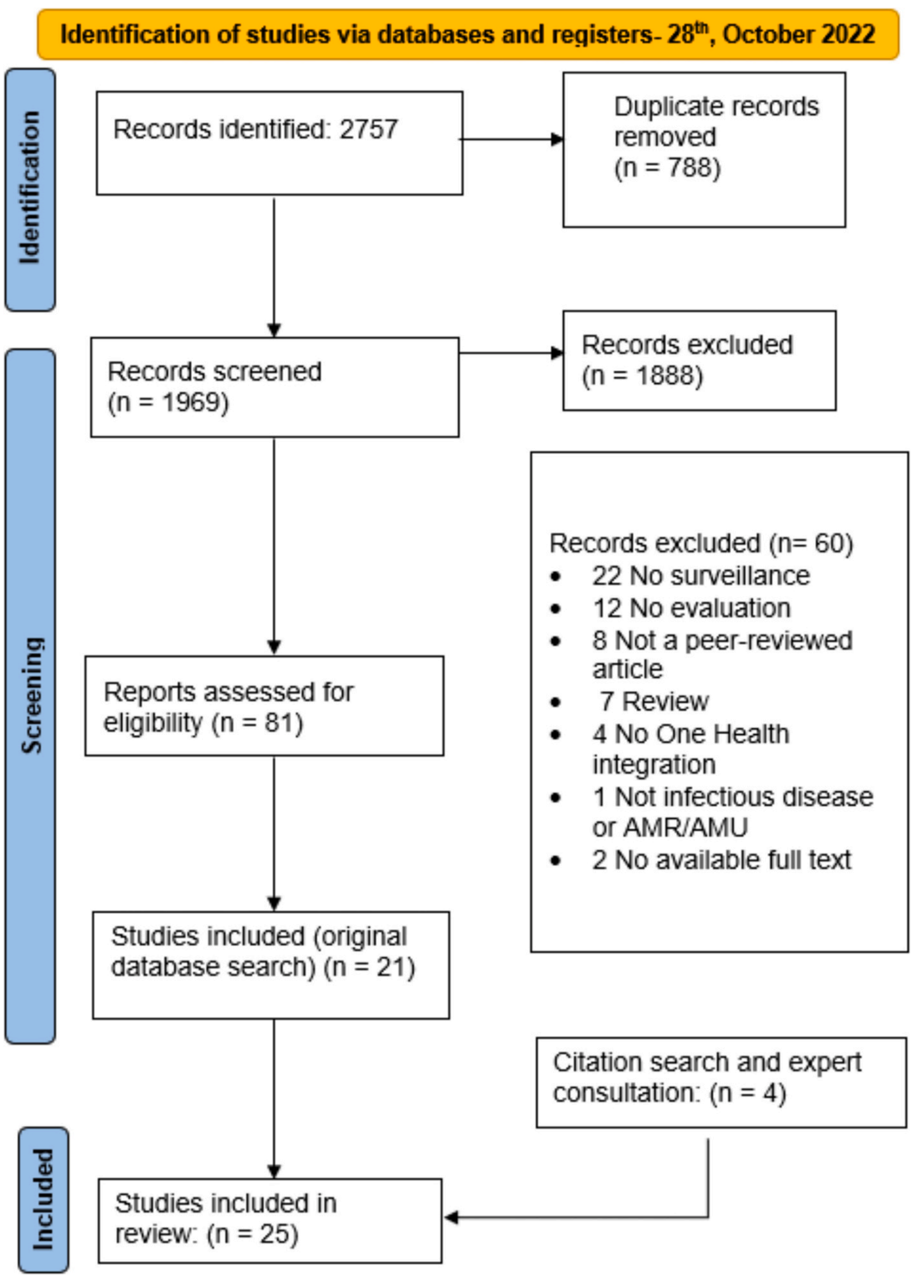

Fig. 1. - PRISMA flowchart.

3.1. Quality assessment

Based on the answers collected via the metaQAT grid, all evaluation tools presented or used in the included studies were relevant for assessing integrated surveillance systems for AMR or ID. In terms of reliability, only five studies did not present their methods with sufficient details and/or not in the main article [13,38,40–42]. Studies were not free from bias; however, limitations and bias to validity were discussed in most (20/25) papers. Regarding their applicability, two papers were interesting for conceptualizing an evaluation process, but did not encompass enough details to be applied directly to answer specific evaluation questions [12,13]. Despite these limitations, the studies evaluated were judged to be of sufficient quality based on the four MetaQAT assessment domains.

3.2. Types of evaluation

A total of 17 different evaluation tools were described or used in the included papers. The components of the system under evaluation and the level of operational detail provided varied across these tools.

Three evaluation types were identified. First, a theoretical evaluation described the system components, the concepts underlying the program theory (information need / formulation of the problem / definition of the objectives / goals / intended outputs, etc.) and the theory linking the surveillance strategies, modalities, and activities to the desired outcomes (theory of change). Second, a process evaluation described organizational, functional, and operational aspects of the surveillance systems and their performance, as well as the quality of the data generated. Third, an impact evaluation included evaluation of surveillance outputs, outcomes and their effects, including economic impacts (Fig. 2).

Most studies ($n = 11$) were classified as presenting a process evaluation only [29–31,33,39,42–47], one as a theoretical evaluation only [34], seven presented two types of evaluation [13,20,35,38,40,41,48] (Fig. 2). No study presented impact evaluation solely. Only the Network for One Health Evaluation (NEOH) and the Integrated Surveillance System Evaluation (ISSE) evaluation tools included all types of evaluations [12,28], and were described in seven papers [4,12,28,36–38,49].

3.3. Characteristics of the three types of evaluation

3.3.1. Theoretical evaluation

Theoretical evaluation was generally framed around the conceptual model of the surveillance system (e.g. logic model or theory of change). Using a stepwise approach, authors first defined the system (e.g. rationale, actors and stakeholders, goals and objectives, assessment of scientific basis and relevance), its boundaries (e.g. space, time dimensions) and the context surrounding it (e.g., socio-economic, governance, value constructs). Second, logical and chronological links were drawn among: 1) the inputs (human, material and financial resources), 2) the activities of the surveillance system and, 3) intended outputs and outcomes [13,27,28,34]. Although most studies using theoretical evaluation adopted this systematic approach, no specific criteria were identified (Tables 1, 2).

3.3.2. Process evaluation

Process evaluation criteria were categorized differently depending on the study and the evaluation questions; examples of these categories

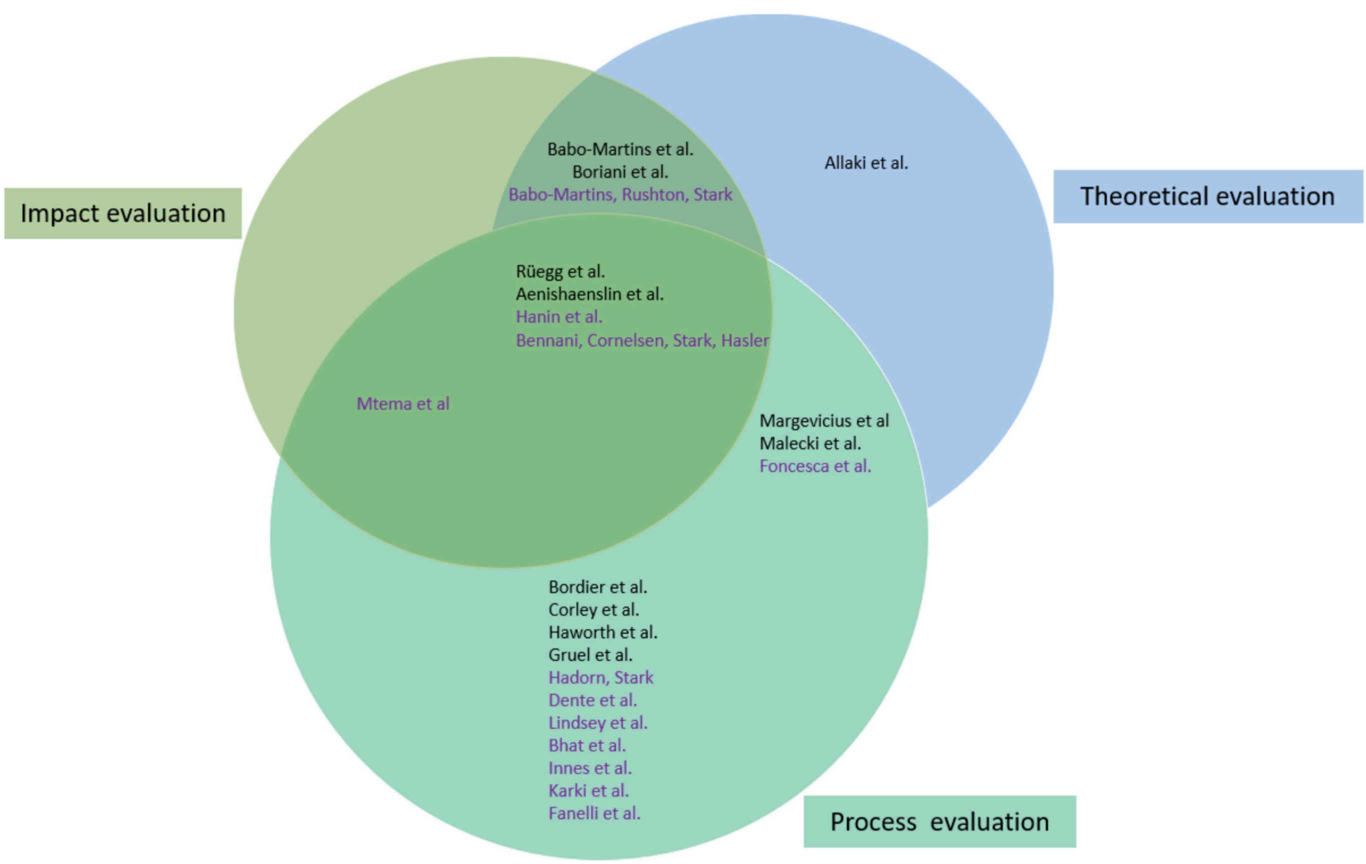

Fig. 2. – Evaluation types (theoretical, process and impact) and associated articles identified in this review; methodological studies are represented in black, case studies are represented in purple.

Note: Two companion articles are not shown in this figure, both are related to methodological studies already identified in the figure above (Aenishaenslin et al., 2019; Rüegg et al., 2017). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Evaluation tools described in methodological studies, evaluation types identified and corresponding evaluation criteria.

Name of the tool (authors)	Reference	Theoretical evaluation	Process evaluation	Impact evaluation
Network for Evaluation of One Health (NEOH) (Ruegg et al.*)	[28]	• Description of the theory of change • One Health-ness assessment: Thinking	One Health-ness assessment: • Planning • Working • Sharing • Learning • Systemic organization	Identification of outputs and outcomes
Biosurveillance datastream framework (Margevicius et al.)	[40]	Definition and a categorization of biosurveillance components: • Knowledge • Process • Goals	Characteristics and attributes of data streams: • Context (disease, population, type) • Category (predefined list, refer to article) • Details (including collection method, source, structure, coverage, etc.)	–
- (Martins, Rushton & Stark)	[13]	Conceptual links between animal health surveillance and public health intervention	–	Economic analysis
Evaluation of Collaboration in a multisectoral Surveillance system (ECoSur) (Bordier et al.) *	[31]	–	• Organizational attributes of the OH collaboration • Functional attributes of the OH collaboration • Organizational indexes of the OH collaboration	–
- (El-Allaki, Bigras-Poulin & Ravel)	[34]	Stepwise analysis of surveillance concepts and their appropriateness	–	–
- (Corley et al.) *	[33]	–	Eight families of attributes and 40 individual attributes for the characterization of event-based biosurveillance	–
Integrated Surveillance System Evaluation framework (ISSE framework) (Aenishaenslin et al.)*	[12]	• Level 1: Integration of a OH approach	• Level 1: Integration of a OH approach • Level 2: Production of OH information and expertise • Level 3: Generation of actionable knowledge	• Level 4: Influence on decision-making • Level 5: Contribution to desirable outcomes
- (Malecki, Resnic, Burke)*	[35]	• Assessment of scientific basis and relevance	• Analytic soundness • Feasibility • Interpretation • Utility	–
One Health Evaluation of Antimicrobial Use and Resistance Surveillance (OHE-AMURS) tool (Haworth et al.) *	[30]	–	Assessment of 36 components based on 5 stages of program development and 7 program sustainability elements	–
- (Gruel et al.) *	[29]	–	Evaluation of One Health Implementation regarding: • Governance • Partnership • Resources	–
- (Boriani et al.)	[48]	System definition: • Aim • Actors and stakeholders • Space and time • Restrictions/ boundaries	–	Consequences identification (outputs/ outcomes)

* Refer to article for full list of criteria.

include organizational criteria and functional or technical criteria (Tables 1 and 2). Organizational criteria looked at the planning strategies and working modalities, this also involved the resources and other factors that could affect the collaborative activities (governance strategies, partnerships, etc.) [28–31]. Functional evaluation used mainly technical criteria looking at the performance of the system (e.g. readiness for operational use, sensitivity to detect health events, robustness against external changes, etc.) [32,33,35]. Utility was also used to assess operational aspects related to surveillance data, such as ease of accessibility, availability, etc. [32]. In addition, some tools looked into the implementation process, namely the One Health Evaluation—Antimicrobial Use and Resistance Surveillance (OHE-AMURS) matrix, which was developed to guide program development in the context of AMR surveillance, using elements such as: funding, partnership, adaptability, strategic planning, and enabling policies [30] (Table 1).

3.3.3. *Impact evaluation*

Impacts ranged from immediate outcomes such as stakeholders' satisfaction to more long term tangible impacts on targeted populations such as health impacts [20,28,48], and were assessed on three levels, namely: 1) identification of outputs and outcomes of the system [27,28,35]; 2) influence of the system's outputs and outcomes on decision-making [12] and; 3) the contribution of the system's outputs and outcomes to achieving ultimate impacts [12]. Economic analysis was explicitly presented in only one tool [13]. The latter linked the costs directly and indirectly related to the surveillance activities, with the benefits derived from the surveillance, translating in health impacts. Cost identification and cost analysis were mentioned in two additional tools [33,35] (Tables 1, 2).

3.4. *Other approaches*

Other approaches to evaluation were described in eight case studies and looked mainly at process evaluation (Table 2). Three used the

Table 2
- Evaluation tools described in case studies, surveillance system evaluated, evaluation types identified and corresponding evaluation criteria.

Name of the tool (authors)	Surveillance system evaluated	Reference	Theoretical evaluation	Process evaluation	Impact evaluation
Network for Evaluation of One Health (NEOH) (Fonseca et al.)*	Cysticercosis surveillance system in Portugal	[38]	Description of the Surveillance system	OH-ness assessment of the surveillance system	–
- (Babo Martins, Rushton, Stark)	Campylobacter surveillance in Switzerland	[19]	Conceptual representation of the links between surveillance activities, interventions in animal and public health sectors and benefits generated	–	Cost-benefit analysis
Network for Evaluation of One Health (NEOH) (Hanin et al.)*	Southern African Centre for Infectious Disease Surveillance	[37]	Description of the surveillance system	OH-ness assessment of the surveillance system	Identification of outputs of the system in relation with the theory of change
Scenario tree modelling (Hadorn, Stark)	Bovine tuberculosis surveillance in Switzerland	[41]	–	Assessment and optimization of surveillance sensitivity	–
Business process modelling notation (Dente et al.)*	Arbovirus infections surveillance in the Mediterranean and black sea region	[39]	–	Assessment of the inter-sectoral approach through visual representation (BPMN) Three levels of integration to assess: • Policy/institutional • Data collection/data analysis • Dissemination	–
CDC updated guidelines for evaluating public health surveillance (adapted) (Mtema et al.)	Surveillance System for Rabies in Tanzania	[47]	–	• Case detection capacity for human rabies • Timeliness of reporting • Completeness of surveillance according to standard methods	Cost analysis of the surveillance system
- (Lindsey et al.)	National arboviral surveillance system in the US (ArboNET)	[42]	–	Evaluation of performance and data utility as perceived by the stakeholders	–
ISSE framework NeOH ECoSuR (Bennani, Cornelsen, Stark, Hasler)	AMU/AMR surveillance in England	[36]	Links between activities and outputs, and outcomes in the surveillance system for AMR in England	• Data and information sharing • Cross-Sectoral Collaboration and integration on AMR surveillance in England	• Production of One Health outputs and outcomes • Impact of surveillance information on decision making • Impact of the decisions attributable to integrated activities
CDC updated guidelines for evaluating public health surveillance (Bhat et al.)	Kyasanur Forest Disease in Shivamogga, Karnataka – India	[43]	–	• Simplicity • Flexibility • Usefulness • Acceptability • Timeliness • Representativeness • Positive predictive value	–
CDC updated guidelines for evaluating public health surveillance (Innes et al.)	Avian influenza surveillance in Thailand	[44]	–	• Simplicity • Flexibility • Data quality • Acceptability • Sensitivity • Predictive value positivity • Representativeness • Timeliness • Stability • Transparency • Interoperability • Security	–
The information value chain - IVC The Data-Information System-Context – DISC (Karki et al.)	Chad guinea worm surveillance information system	[45]	–	IVC-DISC contextual analysis matrix Data quality: • Completeness • Timeliness • Handling • Sharing and communication	–
Capture- recapture method (Fanelli et al.)	OIE-WAHIS surveillance data on tularemia	[46]	–	Sensitivity of international notifications	–

[*] Refer to article for full list of criteria.

conventional Centers for Disease Control and Prevention (CDC) updated guidelines for evaluating public health surveillance systems; the latter assesses technical indicators: simplicity, flexibility, data quality, acceptability, sensitivity, predictive value positive, representativeness, timeliness and stability [41,44,45]. One case study used, in addition, three novel metrics, namely transparency (extent to which information can be and is shared across member agencies), interoperability (ability and ease for information to cross intra- and inter-agency boundaries), and security (protective mechanisms to prevent data compromise) [45]. Methods such as scenario tree modelling and capture-recapture analysis were used in two other case studies to assess the surveillance systems' performance, more specifically their sensitivity [43,47]. Another case study combined two conceptual models, namely the Information Value Chain (IVC) model and the Data-Information System-Context (DISC). The IVC model looks at the data collection and processing steps (e.g., planning, capture, use, analysis, evaluation) while the DISC model maps the personal, organizational, and environmental context that enables the conversion of raw data into actionable information. The integration of these two models resulted in a matrix to assess the data flow of the surveillance system. Evaluation criteria included data quality indicators such as completeness, timeliness, handling, sharing and communication [46].

In another paper, an online questionnaire was used to collect information about data utility and the performance of the system as perceived by the stakeholders [42].

Finally, one case study used Business Process Modelling Notation (BPMN), which is a standardized graphical notation used for modelling various types of processes, to graphically represent evidence of intersectoral integration [39] (Table 2).

3.5. Evaluation of one health integration

Elements related to the evaluation of One Health integration were included in four methodological [12,13,29,31] and four case studies [36–39]. The ISSE was the only tool specifically designed to conceptualize and guide the evaluation of OH integration in a surveillance system for AMR [4,12]. It consists of five evaluation levels: 1) planning and implementation of integrated surveillance activities, 2) information and expertise related to integrated surveillance, 3) generation of actionable knowledge, 4) decision-making as a result of integrated surveillance, and 5) contribution of integrated surveillance to desirable outcomes. However, this conceptual framework does not propose specific evaluation criteria for each level.

The OH-ness assessment tool of the NEOH framework looks at different infrastructure and operational aspects that help foster integration of OH principles within the system [50]. This includes representativeness of different disciplines and sectors within the system, transdisciplinary work and interactions, partnership, and engagement of relevant stakeholders, supporting governance mechanisms and leadership as well as learning processes and sharing infrastructures available within these initiatives [28,49].

The Evaluation of the Collaboration in Surveillance systems (ECoSuR) tool [31] is designed to assess collaboration strategies, modalities, and activities in a multisectoral surveillance system. ECoSuR includes 75 specific criteria (evaluation questions) used to score 23 organizational attributes, nine functional attributes and three collaboration indexes.

Another tool was developed by Gruel et al. to assess the implementation of the OH approach in surveillance and control initiatives [29]. This framework is based on 13 criteria investigating key aspects of governance, partnership, and resources necessary to implement and sustain such programs.

Finally, the BPMN model, described previously, was applied to assess three levels of integration: policy/institutional, data collection/data analysis and dissemination in a surveillance systems for arboviral diseases [39] (Table 2).

3.6. Application of evaluation tools to AMR and ID surveillance

The NEOH tool was used in three case studies: surveillance of cysticercosis in Portugal [38], the Southern African Centre for infectious diseases surveillance [37], and the integrated surveillance system for AMU/AMR in England [36]. Articles reporting on the use of this tool highlighted its comprehensiveness to evaluate OH integration despite some barriers in its application, including the complexity of some concepts used and the large amount of data required [38].

The ISSE framework was applied to AMR surveillance system in England. This application identified a gap in available metrics to assess some of the indicators included in the tool (e.g. capacity of the system to produce OH information) [36].

Similar to NEOH and ISSE tools, the economic evaluation framework described previously [13] was used to conduct a cost-effectiveness analysis of *Campylobacter* spp. surveillance in Switzerland in a OH context [51]. This case study revealed that the validity of results derived from economic assessment relies strongly on the availability, completeness and accuracy of data used.

Finally, the CDC guidelines were recognized as straightforward and easy to use. However, though they are applicable to integrated surveillance systems, they focus only on technical aspects [41,44,45].

4. Discussion

To our knowledge, this is the first systematic review to describe peer-reviewed evaluation tools that can be adapted for OH integrated surveillance systems for AMR and ID. Seventeen different tools were identified. Theoretical, process, and impact evaluation were the three main types of evaluation used. At least five tools specifically evaluated OH integration and focused mainly on partnerships, multisectoral collaboration or coordination mechanisms.

Program evaluation is a systematic process that requires defining the scope, purpose, and specific objectives of the evaluation; setting an evaluation plan; identifying information sources and engaging the appropriate stakeholders for data collection, analysis and validation [28,31,52,53]. Evaluating complex surveillance systems poses significant challenges due to the interconnected and intertwined nature of surveillance components and activities. It is therefore crucial to have access to a range of evaluation tools, approaches, and guidance on how and when to use them. Our findings contribute to a deeper understanding of the multifaceted challenges and opportunities in evaluating such integrated systems as well as the practical considerations to keep in mind while conducting evaluation.

Understanding the system components and how they relate to each other is crucial for grasping complex OH surveillance systems. This process was described in papers where theoretical evaluation was used to establish a logic model, identifying key elements as well as gaps in surveillance [28,34]. These evaluations were important at the early stages of the implementation as they offer guidance to stakeholders on the relevant actors to include as well as important information sources and types of data [13,35,38,40]. Cross-sectoral collaborations are also important aspects of OH integrated surveillance systems which can be evaluated through different types of evaluations (theoretical, process and impact) and at different levels of the surveillance process [12,16]. In this study, we found only five case studies that looked at the evaluation of OH surveillance from this angle [36–39,51]. This paucity of examples might be related to the complexity of these evaluations and the need for detailed information [36].

Process evaluation was described in more than three quarters of the eligible articles. The ease of access to data required to complete this task and the interest in technical assessments of surveillance systems could explain the popularity of this type of evaluation. However, the functional criteria usually included in process evaluation have a limited scope since they focus on system's operationalization but do not inform well on the outputs generated by surveillance, nor their wider impacts.

This study reiterates the lack of structured tools and methods available to evaluate the broader impacts of OH surveillance systems which was highlighted before by several authors [11,15,54], and this gap limits our understanding of the long-term socio-economic impacts and potential returns on investment associated with OH integrated approach to surveillance and interventions. Some of the highlighted challenges in conducting economic evaluation of ID and AMR integrated surveillance included the need for access to extensive and detailed information, as well as for baseline or contrafactual scenarios for comparison purposes [15,20].

Collaborative efforts between different disciplines and sectors have been repeatedly highlighted as crucial elements in mitigating complex health threats [28,55–59]. However, the environmental sector and environmental considerations in OH initiatives are often neglected [60,61]. Interestingly, three evaluation tools identified in our review were based on biosurveillance and environmental health surveillance [33,35,40]. However, further applications of these tools are needed to prove their suitability for integrated surveillance systems of AMR and ID.

This study has some limitations. First, given that our search strategy focused solely on peer-reviewed literature, we may have missed some tools and evidence derived from the grey literature. Examples of such tools are the FAO Progressive Management Pathway for Antimicrobial Resistance (FAO-PMP-AMR) [62], the FAO Assessment Tool for Laboratories and AMR Surveillance Systems (FAO-ATLASS) [63], and the OASIS evaluation tool, designed by the French agricultural research and cooperation organization (CIRAD) to assess the quality of epidemiological surveillance [64].

In addition, this review focused on evaluation tools for (or adaptable to) OH integrated surveillance systems for AMR and ID and this may have led to the omission of relevant evaluation tools that were applied to other contexts.

5. Conclusion: future directions and policy considerations

Our systematic review reveals a lack of suitable tools and methods to support the evaluation of important impacts of integrated OH surveillance for AMR and ID such as improved decision-making and enhanced effectiveness of resulting interventions. These effects of integrated approaches remain partially documented, and this can hinder the investment of resources in OH. This calls for the development, use and validation of a more comprehensive methodology for the evaluation of surveillance systems, taking into account their organizational attributes, their operationality as well as the impacts of surveillance. Building on tools that have already integrated the OH principles in their evaluation process, such as the ISSE, ECoSur and NEOH frameworks, could be a starting point.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT 3.5 for error checking and/or readability and clarity improvements. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Credit authorship contribution statement

Sarah Mediouni: Writing – review & editing, Writing – original draft, Validation, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Claire Ndione:** Data curation. **E. Jane Parmley:** Writing – review & editing, Methodology, Conceptualization. **Thomas G. Poder:** Writing – review & editing, Methodology, Conceptualization. **Hélène Carabin:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Cécile Aenishaenslin:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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