

GLOBAL HEALTH AND EMERGING DISEASES: INTERDISCIPLINARY STRATEGIES FOR SURVEILLANCE AND RESPONSE IN POST-PANDEMIC SCENARIOS

Artemis de Araujo Soares

Corresponding email: artemissoares@gmail.com

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ABSTRACT

Objective: to analyze recent scientific evidence on interdisciplinary strategies for surveillance and response applied to emerging diseases in post-pandemic scenarios, focusing on contributions to strengthening global health. Method: this is an integrative literature review, descriptive and analytical in nature, developed from the selection of 20 real scientific studies published between 2020 and 2025, with an emphasis on research on epidemiological surveillance, genomic surveillance, environmental surveillance, digital surveillance, artificial intelligence, One Health approach, and community surveillance. The analysis of the studies was conducted through thematic and interpretative synthesis, allowing the organization of findings into converging scientific axes. Results: the studies showed that, in the post-pandemic period, health surveillance systems have been progressively reconfigured by more integrated, hybrid, and interdisciplinary models. Highlighted were the expansion of surveillance in wastewater, the strengthening of genomic surveillance, the use of digital tools and artificial intelligence for early warning, as well as the relevance of community surveillance and the one health approach in increasing the sensitivity and reach of response systems. It was observed that the effectiveness of surveillance depends not only on technological innovation but also on governance, interoperability, territorial intelligence, and intersectoral cooperation. Conclusion: preparation for future health emergencies requires multiscale, sustainable, and adaptive surveillance systems capable of integrating different data sources and different levels of public health action. The analyzed literature reinforces that strengthening global health will depend on the articulation between technology, territory, social participation, and institutional coordination.

Keywords: epidemiological surveillance; emerging infectious diseases; one health; pandemic preparedness.

INTRODUCTION

The emergence and re-emergence of infectious diseases in recent decades have solidified global health as a strategic field for international health security, especially in light of increased human mobility, climate change, accelerated urbanization, pressure on ecosystems, and the growing interface between humans, animals, and the environment [1,2]. In this context, the COVID-19 pandemic not only highlighted historical weaknesses in surveillance and response systems but also accelerated structural transformations in how outbreaks, epidemics, and events of public health relevance are detected, monitored, and controlled [1,3,4].

The post-pandemic scenario has imposed a critical review of traditional epidemiological surveillance models. Systems based exclusively on clinical notification and laboratory confirmation have proven insufficient to respond, with adequate speed and sensitivity, to the dynamics of transmission of emerging pathogens on a global scale [1,15,17]. In response to these limitations, recent literature has begun to emphasize the need for interdisciplinary and integrated approaches capable of articulating

laboratory, epidemiological, genomic, environmental, digital, and community surveillance in more resilient and responsive architectures [2,6,10,14].

Among the most relevant advances, environmental surveillance of wastewater has gained prominence as an early warning tool for viral circulation in communities, schools, and urban areas, allowing for population monitoring even when there is clinical underreporting or testing limitations [5-9]. At the same time, genomic surveillance has established itself as an essential component for identifying variants, tracking transmission chains, and understanding the molecular evolution of pathogens, particularly relevant in scenarios of rapid international dissemination [10-13]. These mechanisms have expanded the analytical capacity of public health systems, especially when integrated with clinical, territorial, and hospital data [4,8,11].

In addition, the incorporation of artificial intelligence, predictive modeling, and digital syndromic surveillance is redefining the concept of early detection in global health. Anomaly detection algorithms, data analysis

Unconventional and dynamic monitoring systems have shown potential to identify emerging epidemiological patterns before the consolidation of traditional indicators, favoring more timely responses [12,15-17]. This technological transition, however, does not eliminate the need for governance, methodological validation, and integration with institutional structures capable of transforming early signals into coordinated public health actions [14-17].

Another central aspect of the contemporary debate is the strengthening of participatory, territorial, and community strategies. Studies conducted in Brazil, Indonesia, and Niger show that community-based surveillance can enhance the reach of formal systems, improve sensitivity for detecting local events, and strengthen epidemiological intelligence in contexts of social inequality, low health-care coverage, and limited laboratory capacity [18-20]. This perspective brings surveillance closer to a more democratic and contextualized logic, recognizing that the response to emerging diseases depends not only on advanced technologies but also on local care networks, risk communication, and intersectoral mobilization [3, 18-20].

From this perspective, the One Health approach has become especially relevant in the post-pandemic period, proposing the integration of human health, animal health, and environmental health as a foundation for prevention, preparedness, and response to complex infectious threats [2]. This paradigm is particularly important in a scenario marked by the persistence of zoonoses, the risk of spillover, and the expansion of sanitary events associated with ecological imbalances and social vulnerabilities. Thus, thinking about global health surveillance in the present implies overcoming fragmented models and advancing towards interdisciplinary, adaptive, and cooperative systems, capable of operating at multiple scales and contexts [1,2, 14].

In light of this panorama, this integrative review aims to analyze recent scientific evidence on interdisciplinary surveillance and response strategies applied to emerging diseases in post-pandemic scenarios, emphasizing methodological advances, the interfaces between different modalities of surveillance, and the contributions of these approaches to strengthening preparedness and response in global health.

METHODOLOGY

This is an integrative literature review, descriptive and analytical in nature, developed with the aim of synthesizing scientific evidence on interdisciplinary strategies for surveillance and response applied to emerging diseases in post-pandemic scenarios. The integrative review was chosen because it allows for the gathering, analysis, and interpretation of studies with different methodological designs, favoring a comprehensive understanding of complex phenomena related to global health, epidemiological surveillance, and intersectoral responses to emerging health threats.

The construction of the review followed structured stages: definition of the theme and guiding question, establishment of eligibility criteria, systematic search in databases, selection of studies, extraction of relevant information, analytical categorization, and interpretative synthesis of findings. The question that guided this review was: what interdisciplinary strategies for surveillance and response have been described in the recent literature as relevant for addressing emerging diseases in

post-pandemic scenarios, considering the contexts of global health?

The bibliographic search was directed towards internationally recognized databases for their relevance and quality of indexing in health and biomedical sciences, with an emphasis on PubMed/MEDLINE, complemented by recent international scientific literature already aligned with the thematic scope of the review. For the location of the studies, descriptors and free terms in English were used, combined by Boolean operators, covering the main concepts of the topic, such as: global health, emerging infectious diseases,

post-pandemic, surveillance, public health surveillance, genomic surveillance, wastewater surveillance, community-based surveillance, digital surveillance, One Health, outbreak response, and pandemic preparedness. The strategy was structured to retrieve studies that addressed, directly or applied, the systems of surveillance, preparedness, and response to emerging infectious diseases after the COVID-19 pandemic.

The inclusion criteria adopted were: original articles, observational studies, applied analyses, and reports of... implementation, studies

Methodological and research studies with empirical contributions to health surveillance, preferably published between 2020 and 2025, in English, Portuguese, or Spanish, available in full text or with sufficient metadata for scientific evaluation, and relevant to the central theme of the review, were included. Studies addressing at least one of the following areas were included: genomic surveillance, environmental surveillance, syndromic surveillance, digital surveillance, community surveillance, epidemiological intelligence, preparedness, One Health, or interdisciplinary response strategies. Editorials, letters to the editor, opinions without empirical basis, exclusively normative documents, duplicate texts, studies without a direct relationship to emerging diseases, or studies without a practical contribution to the debate on global health surveillance and response were excluded.

The selection of studies occurred in successive stages. Initially, an exploratory reading of the titles and abstracts was carried out to identify thematic relevance. Subsequently, the potentially eligible texts were analyzed for their adherence to the objective.

From the review itself, to the type of methodological contribution and relevance to post-pandemic scenarios, a final sample of 20 real studies was selected after screening. These were considered sufficient to form a robust and international analytical base, with geographical, methodological, and thematic diversity. This sample included investigations developed in different contexts, including Europe, Latin America, the Caribbean, Asia, and Africa, which broadened the capacity to interpret health surveillance from a global health perspective.

To organize the synthesis, an extraction matrix was developed containing the following elements: author and year of publication, main thematic axis, type of study or methodological approach, application context, and main contribution to surveillance and response systems. Based on this matrix, the studies were grouped by thematic convergence, allowing the construction of analytical categories related to the reconfiguration of surveillance systems in the post-

pandemic period, the use of emerging technologies for early detection, the integration between environmental and genomic surveillance, the role of artificial intelligence and digital surveillance, as well as...

as well as the relevance of community strategies and the One Health approach.

Since this is an integrative review using secondary data from the scientific domain, without direct involvement of human beings, there was no need for submission to an Ethics Research Committee. It is emphasized, however, that the principles of integrity academic, rigor

methodological and fidelity to the consulted scientific literature were observed. The final analysis of the data was conducted in a descriptive-interpretative manner, seeking not only to gather the findings but also to identify trends, gaps, and practical implications for strengthening global health surveillance and response systems in the face of future health emergencies.

RESULTS

The Analysis of the Included Studies

showed that, in the post-pandemic scenario, global health surveillance has been ongoing progressively restructured based on more integrated models, responsive and interdisciplinary. Together, the selected works indicate that systems focused exclusively on clinical notification and laboratory confirmation are insufficient to respond quickly, sensitively, and effectively to emerging diseases,

especially in contexts of high population mobility, territorial inequality, and simultaneous circulation of multiple infectious agents [1,4,15,17]. The synthesis of findings allowed for the organization of results into five scientific thematic axes: reconfiguration of public health surveillance systems; environmental and metagenomic surveillance; genomic surveillance and molecular intelligence; digital, syndromic surveillance and artificial intelligence; and community surveillance linked to the One Health approach [1,2,6,10,14].

Table 1. Synthesis of the Thematic Axes Identified in the Integrative Review

Thematic axis	Studies	Synthesis of key findings
Reconfiguration of public health surveillance systems	1, 3, 4, 17	They highlight the need for adaptive, multi-level systems with integration between clinical, territorial, and operational data for

Thematic axis	Studies	Summary of the main findings
		Faster response.
Environmental surveillance and metagenomics	5, 6, 7, 8, 9	They demonstrate that wastewater and metagenomic approaches enhance early detection and complement traditional epidemiological surveillance.
Genomic surveillance and molecular intelligence	10, 11, 12, 13, 14	They show that sequencing, bioinformatics, and molecular analysis are central to tracking variants, viral introductions, and emerging threats.
Digital surveillance, syndromics, and artificial intelligence.	12, 15, 16, 17	They indicate that AI, anomaly detection, and unconventional data strengthen early warning, forecasting, and dynamic monitoring.
Community surveillance and the One Health approach	2, 18, 19, 20	They reinforce the role of local networks, social participation, and the integration of human, animal, and environmental health in emergency response.

Regarding the reconfiguration of public health surveillance systems, studies have indicated that the COVID-19 pandemic acted as a catalyst for revising traditional health monitoring models.

Stoto et al. demonstrated that, in the European experience, the ability to articulate testing, screening, situational analysis and coordination between institutional levels was crucial for the initial response, showing that the effectiveness of surveillance depends on the functional integration between different components of the system [1]. In this way

convergent, De La Cerda et al. showed what interventions

Territorialized, data-driven, and precision public health-oriented approaches can enhance the effectiveness of outreach actions and target more vulnerable populations [3]. Fernandes et al., in turn, identified that pre-hospital care data can also contribute to preparedness by providing early signs of epidemiological and healthcare pressure in territories with greater operational fragility [4]. Post et al. added that dynamic surveillance, based on

longitudinal trends, is especially useful for guiding responsive decisions during rapidly evolving events [17].

In the field of environmental surveillance and metagenomics, a strong methodological and operational advance has been observed. Hassard et al. demonstrated the feasibility of near-source monitoring in schools, indicating that surveillance in wastewater can capture viral circulation even in specific environments with great epidemiological importance [5]. Besijn et al. evidenced that on-demand sewage surveillance was able to support responses to local outbreaks in the Netherlands, including applications for SARS-CoV-2 and MPXV, reinforcing its utility in focused population contexts [6]. At the national level, Radvák et al. showed that SARS-CoV-2 surveillance in sewage can be broadly operationalized and complement traditional systems, expanding the monitoring epidemiological [7]. Child et al. added that the comparison between metagenomic methods and targeted approaches in environmental samples has relevant implications for the choice of more sensitive laboratory strategies for detecting emerging human pathogens [9]. Although with less interpretative weight as it is a pre-

Holm et al. also suggested that the integration of sewage, seroprevalence, and hospitalization may enhance the predictive capacity of surveillance systems [8].

Regarding the axis of genomic surveillance and molecular intelligence, the findings showed that genomic sequencing has consolidated as a central component of the contemporary architecture of global health surveillance. Sahadeo et al. reported the implementation of genomic surveillance of SARS-CoV-2 in 17 territories of the Caribbean and highlighted that its sustainability in resource-limited contexts depends on regional cooperation, technical training, and continuous laboratory infrastructure [10]. Similarly, Su et al. demonstrated, in Cambodia, that genomic epidemiology allowed tracking multiple viral introductions and understanding transmission behavior during the early pandemic phases [11]. Zhao et al. expanded this field by showing that artificial intelligence models based on haplotypes can contribute to assessing emerging variants and mutations with greater analytical agility [12]. Bohl et al. evidenced, in a resource-scarce scenario in Southeast Asia, the potential of a global metagenomic platform.

for the identification of disease-causing pathogens [13], while Downie et al. emphasized that agnostic surveillance based on metagenomics requires institutional governance and strategic participation from laboratory networks and federal agencies for its sustainable consolidation [14].

In the realm of digital surveillance, syndromic surveillance, and artificial intelligence, studies have shown that the incorporation of algorithms and unconventional data has enhanced the capacity for early detection of infectious events. Wen et al. demonstrated that anomaly detection models applied to syndromic surveillance can differentiate outbreaks with similar clinical presentations, favoring early alerts for COVID-19 and other emerging flu syndromes [15]. Movahedi Nia et al. indicated that strategies based on deep learning and alternative data have the potential to structure real-time surveillance systems, forecasting, and early warning for respiratory outbreaks [16]. Zhao et al. also contributed to this area by showing that advanced computational tools can strengthen the dynamic assessment of variants [12]. Together, these studies suggest that digital surveillance does not replace conventional epidemiological surveillance, but rather it

strategically complements, especially when associated with well-defined analytical structures and institutional integration [12, 15-17].

In the axis of community surveillance, participatory and One Health approach, the results showed that the response to emerging diseases also depends on the social and territorial reach of epidemiological intelligence systems. Wakimoto et al. demonstrated that the Brazilian experience with COVID-19 and zoonoses reinforces the centrality of the One Health approach for preparedness and response, by integrating human, animal, and environmental health within the same analytical logic [2]. Wittwer et al. demonstrated, in Brazil, that participatory surveillance based on self-reporting can track epidemiological trends and

complement formal systems [18]. Craig et al. highlighted, in Indonesia, that community surveillance strengthens the generation of intelligence for emerging infectious diseases [19]. In the same direction, Maazou et al. showed that community-based surveillance contributed to the response to COVID-19 in Niger, especially when supported by training and logistical support [20]. These studies converge in indicating that advanced technologies, in isolation, are not sufficient: the effectiveness of

Post-pandemic surveillance also depends on local networks, social participation, risk communication, and intersectoral coordination [2, 18-20].

In a transversal manner, the synthesis of the studies demonstrated three central trends. The first was the expansion of hybrid surveillance systems, in which clinical, laboratory, environmental, genomic, digital, and community data operate complementarily [1,6, 10, 17]. The second was the increasing emphasis on early detection, highlighting wastewater surveillance, metagenomics, syndromic surveillance, and

artificial intelligence [5-9, 12, 15, 16]. The third was the strengthening of the integration between territory, governance, and interdisciplinarity, especially in contexts marked by resource inequality or greater vulnerability to zoonoses and emerging outbreaks [2,4, 10, 14, 19,20]. Together, the results indicate that surveillance in post-pandemic scenarios tends to be more effective when structured as an interoperable, multiscale system that is sensitive to the ecological, social, and technological dimensions of infectious emergencies [1,2, 14].

DISCUSSION

The findings of this integrative review indicate that the post-pandemic period has consolidated an important inflection point in the field of global health surveillance. If, before COVID-19, many systems still operated with a strong dependence on clinical notifications, laboratory confirmation, and relatively slow bureaucratic flows, recent literature shows a transition to more hybrid architectures, in which different modalities of surveillance begin to act complementarily [1,6, 10, 14]. This movement represents not only technological innovation but a

conceptual reconfiguration of surveillance itself, now understood as a continuous process of producing epidemiological intelligence, intersectoral articulation, and adaptive response at multiple scales [1,2].

On the first analytical plane, the review suggests that the main lesson from the pandemic scenario was the insufficiency of isolated models. The European experience demonstrated that the effectiveness of the response depends on the integration of testing, tracing, laboratory capacity, federal coordination, and timely use of data for decision-making [1]. This finding

It dialogues with territorial and operational studies that highlight the value of pre-hospital data and targeted precision strategies in public health to anticipate care pressure and identify the most vulnerable areas [3,4]. Practically speaking, this means that preparedness should not be reduced to the availability of supplies or beds, but must incorporate surveillance systems capable of transforming scattered signals into coordinated action. The international discussion, therefore, shifts the focus from surveillance as a mere record of cases to surveillance as a strategic infrastructure for health governance [1,4,17].

Another central point refers to the expansion of environmental and metagenomic surveillance as early warning instruments. The included studies show that monitoring of wastewater has become one of the most important methodological innovations of recent times, especially due to its ability to capture viral circulation at the population level, even when there is clinical underdiagnosis, low demand for testing, or delays in reporting [5-9]. The experience of Rotterdam-Rijnmond is particularly illustrative, as it demonstrates that on-demand sewage surveillance can support outbreak response.

located, detect transmission patterns in small populations and even contribute to the monitoring of different viruses, such as SARS-CoV-2 and MPXV [6]. This reinforces that environmental surveillance should not be seen merely as a complementary research tool, but as an operational component with the potential for integration into official public health systems.

However, the literature also suggests that the incorporation of these technologies requires interpretative caution and methodological standardization. Although the sensitivity of environmental surveillance is promising, its translation into health decision-making depends on sampling frequency, analytical quality, population context, and coordination with epidemiological and clinical indicators [6,8,9]. The same applies to agnostic metagenomic approaches, which expand the capacity to identify unexpected pathogens, but demand laboratory infrastructure, qualified bioinformatics, and governance models that support their continuous adoption [13, 14]. Thus, the significant contribution of this axis lies not only in increasing diagnostic sensitivity but also in opening a new logic of prospective, ecosystemic surveillance that is less

dependent on the late confirmation of symptomatic cases.

In the context of genomic surveillance and molecular intelligence, studies reinforce that the pandemic has transformed sequencing into a central instrument of contemporary public health [10-14]. The case of the Caribbean is especially relevant because it shows that, even in resource-limited contexts, collaborative networks and regional capacity building can enable genomic surveillance systems with a real impact on public health decisions [10]. This finding is important for global health because it shifts the discussion from a purely technological axis to the axis of equity: it is not enough to recognize the value of genomics; it is necessary to discuss who has access to it, with what sustainability, and with what degree of integration into epidemiological surveillance systems [10,11]. From this perspective, genomics is understood not only as a sophisticated laboratory tool but also as a strategic technology for health sovereignty and rapid response to the emergence of variants, viral reintroductions, and new pathogens.

The discussion also highlights that the use of artificial intelligence, analysis of

Anomalies and unconventional data significantly broaden the horizon of post-pandemic surveillance [12,15,16]. These resources allow for the identification of early patterns, processing of large volumes of data, and generation of predictive models with potential application in rapidly evolving epidemiological scenarios. However, the literature does not support a techno-deterministic reading.

Instead of replacing classical systems, AI and digital surveillance seem to produce better results when they operate complementarily to structured epidemiological surveillance, laboratory capacity, and institutional governance [12,15-17]. In other words, digital innovation is more robust when integrated into interoperable and well-coordinated systems, rather than when it acts in parallel or disconnected from health routines. This point is particularly important to avoid the illusion that algorithms, by themselves, solve historical problems of fragmentation, territorial inequality, and low responsiveness.

In the axis of community surveillance and the One Health approach, the review shows that technological sophistication, while necessary, is not sufficient to sustain effective responses to emerging diseases [2,18-20]. The

Studies conducted in Brazil, Indonesia, and Niger demonstrate that community-based surveillance increases the detection capillarity, strengthens sensitivity to local events, and reduces zones of epidemiological silence, especially in territories with fragile formal coverage [18-20]. The Brazilian study on COVID-19 and zoonoses adds that preparedness and response need to more consistently incorporate the interface between human, animal, and environmental health, a dimension that has become unavoidable in the post-pandemic debate [2]. Thus, the One Health approach emerges not only as a theoretical reference but as a practical foundation for surveillance policies that are more coherent with the ecological complexity of emerging diseases.

This interpretation has direct implications for countries marked by regional heterogeneity, infrastructure inequality, and the coexistence of biological, social, and environmental risks. In such contexts, excessively centralized surveillance systems or

those exclusively dependent on high-complexity laboratories tend to reproduce asymmetries in detection and response. The reviewed literature suggests that more resilient models are those

capable of combining high technology with territorial intelligence, community participation, cooperation

Inter-institutional and adaptation to local specificities [2,6,10,18-20]. This is particularly relevant for middle-income countries, where the challenge is not only to incorporate innovation but to ensure that this innovation is operationally sustainable and equitably distributed.

From a critical standpoint, this review also highlights some gaps. Part of the literature still heavily focuses on SARS-CoV-2, which, while understandable, may limit generalization to other emerging pathogens with distinct dynamics. Furthermore, there is heterogeneity among study designs, application contexts, and indicators used to assess the effectiveness of surveillance, which complicates direct comparisons. It is also noted that some strategies appear more consolidated in terms of proof of concept than of full institutionalization. Thus, while the identified advances are relevant, the transition from successful experiences to permanent policies still constitutes a substantial challenge for global health.

Contemporary global health.

In summary, the discussion of the analyzed studies supports that surveillance in post-pandemic scenarios tends to be more effective when structured as a hybrid, interdisciplinary, multiscale system oriented by integration. The main contribution of the reviewed literature is to show that future responses to emerging diseases will depend less on singular solutions and more on the ability to combine environmental surveillance, shared.

genomic, digital, community, and territorial in coherent, sustainable, and equitable operational arrangements [1,2,6,10,14]. This understanding reinforces the idea that preparedness for new health emergencies requires not only technological innovation but also organizational reform, cooperative governance, and commitment to global health as a public good

CONCLUSION

This integrative review evidenced that, in post-pandemic scenarios, the surveillance and response to emerging diseases are being progressively reconfigured based on more integrated, interdisciplinary, and technologically enhanced approaches. The studies analyzed demonstrated that traditional models, centered exclusively on clinical notification and laboratory confirmation, tend to present significant limitations in the face of the speed of dissemination of infectious agents, the complexity of ecological and social determinants, and the need for timely responses at different territorial scales [1,4,15,17].

The synthesis of the literature showed that strengthening global health depends on the articulation between multiple modalities of surveillance, including environmental, genomic, syndromic, digital, and community surveillance, operating in a complementary and non-competing manner [5-7,10,14,18-20]. In this sense, wastewater surveillance and metagenomic approaches have stood out as promising tools

for early detection and population monitoring, while genomic surveillance has consolidated itself as a central axis for tracking variants, understanding transmission dynamics, and supporting decision-making in public health [6,9-14]. At the same time, the use of artificial intelligence and systems

Monitoring digital data indicated significant potential for increasing analytical sensitivity and early warning, especially when associated with institutional structures well coordinates [12,15,16].

The findings also reinforced that the response to emerging diseases cannot be sustained solely by technological innovation. The effectiveness of post-pandemic surveillance equally depends on governance, interoperability between systems, laboratory capacity, regional cooperation, territorial intelligence, and social participation [1,10,14,17]. In this context, the One Health approach and community surveillance strategies proved to be particularly relevant, as they enhance the understanding of the interactions between human, animal, and environmental health and strengthen the detection of events in contexts of greater social and health vulnerability [2,18-20].

Thus, it is concluded that preparation for future health emergencies requires the consolidation of hybrid, multiscale, and adaptive systems capable of integrating different data sources and different levels of action in public health. More than incorporating new technologies, the surveillance systems of the post-pandemic period need to be sustainable, equitable, and sensitive to the territorial inequalities that condition the emergence and spread of infectious diseases [2,6,10,19,20]. From a strategic perspective, the reviewed literature supports that the advancement of global health will depend on the ability to transform scientific innovation into applicable epidemiological intelligence, in order to strengthen prevention, preparedness, and response to emerging and re-emerging infectious threats.

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