

# Public health surveillance and the data, information, knowledge, intelligence and wisdom paradigm

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## ABSTRACT

This article points out deficiencies in present-day definitions of public health surveillance, which include data collection, analysis, interpretation and dissemination, but not public health action. Controlling a public health problem of concern requires a public health response that goes beyond information dissemination. It is undesirable to have public health divided into data generation processes (public health surveillance) and data use processes (public health response), managed by two separate groups (surveillance experts and policy-makers). It is time to rethink the need to modernize the definition of public health surveillance, inspired by the authors' enhanced Data, Information, Knowledge, Intelligence and Wisdom model. Our recommendations include expanding the scope of public health surveillance beyond information dissemination to comprise actionable knowledge (intelligence); mandating surveillance experts to assist policy-makers in making evidence-informed decisions; encouraging surveillance experts to become policy-makers; and incorporating public health literacy training – from data to knowledge to wisdom – into the curricula for all public health professionals. Work on modernizing the scope and definition of public health surveillance will be a good starting point.

## Keywords

Public health surveillance; data collection; health information management; population health management; health literacy; learning health system; intelligence.

The definition and scope of public health surveillance may need to be updated, strengthened and extended in view of modern-day progress in knowledge management theories (1, 2) and data strategies (3-5). Instead of the traditional approach of data processing (moving from data to information) (6), the current focus is on moving from data to action (7, 8).

A review of the historical definitions of public health surveillance and related concepts, such as political arithmetic, from 1661 to 2012, identifies little change in these definitions over time (9). Several components have always been included in these definitions, such as collection, analysis, interpretation and dissemination. However, the scope of public health surveillance has always ended at, and has never extended beyond, the dissemination of information. Nsubuga et al. (10) even describe a conceptual model of surveillance and response in terms of

two clearly separate parts: a data generation hemisphere and a data use hemisphere. The data generation hemisphere is public health surveillance, from data collection to analysis, and it includes hardly any public health action. The data use hemisphere, however, is the public health response that begins with interpreting data from the surveillance system and is followed by action taken to control the public health problem of concern. The present-day definition from the World Health Organization (WHO) is: "Public health surveillance is the continuous and systematic collection, orderly consolidation and evaluation of pertinent data with prompt dissemination of results to those who need to know, particularly those who are in a position to take action" (11). Public health surveillance is defined by the United States Centers for Disease Control and Prevention as "the ongoing, systematic collection, analysis, and interpretation

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of health-related data essential to planning, implementation, and evaluation of public health practice” (12). The definitions are compared in Table 1. They are similar. And again, both end at the information dissemination stage. Although both definitions strongly hint at public health actions – including the planning, implementation and evaluation of public health practices – public health surveillance does not include action; it includes only the dissemination of information to those who need to know and to act. However, as Foege et al. (13) stated in 1976, “(T)he reason for collecting, analyzing, and disseminating information on a disease is to control that disease. Collection and analysis should not be allowed to consume resources if action does not follow.” Controlling a public health problem of concern requires a public health response that goes beyond information dissemination.

The Data, Information, Knowledge, Intelligence and Wisdom (DIKIW) model is a framework that explains the way we move from data (D) to information (I), knowledge (K), intelligence (I) and wisdom (W) (1). It builds upon the less complex DIKW pyramid, from knowledge management theory, which proposes that data form the base level of the pyramid and information, knowledge and wisdom form the higher levels, with each level building upon the previous one (2). As suggested by Sharma (14), the whole idea probably originated from the poem *Choruses* from the play *The Rock* by T.S. Eliot in 1934 (15). The poem depicts society losing something of great value due to its technological advances:

The endless cycle of idea and action,  
 Endless invention, endless experiment,  
 Brings knowledge of motion, but not of stillness;...  
 Where is the Life we have lost in living?  
 Where is the wisdom we have lost in knowledge?  
 Where is the knowledge we have lost in information?

Figure 1 is our attempt to summarize and enhance the definitions of DIKIW based on adaptations from various sources. Brief examples are also included.

In this modern era of moving from data to action, it is time to modernize the definition of public health surveillance. This is especially true as “we are drowning in information but starved for knowledge” (16) and “we are drowning in information, while starving for wisdom” (17). Needless to say,

there are deficiencies in the traditional definitions of public health surveillance that focus heavily on the front end (data, information, knowledge) of knowledge management and not on the back end (intelligence and wisdom). Public health surveillance amasses big data, creates massive data sets, carefully cleans all data to ensure accuracy and uses high-power state-of-the-art statistics and analytics to extract information, which then ends up in complex surveillance reports ready for information dissemination (9). At this point, the role of public health surveillance ends. These reports are then passed on to a group of policy-makers who might sometimes lack the level of sophistication in statistical and epidemiological expertise to fully comprehend and appreciate technical concepts (18). Decisions and policies are then made. It is crucial to build the DIKIW framework into curricula in public health literacy training for our communities of public health professionals. The modernization of the definition of public health surveillance could be the beginning of the recognition that public health needs to better understand our world and the connections between health domains and different variables in their interactions with all living and non-living things. A minimum level of knowledge about public health principles and data literacy should be required for all public health professionals. We collect data for a purpose, and that purpose is not to collect more data but to finally reach better knowledge, intelligence and wisdom, which could help in making better decisions and producing better changes for health for all (3-5).

If we match the traditional definitions of public health surveillance with the DIKIW framework, we notice immediately that the definition of surveillance ends at knowledge, without going on to intelligence (actionable knowledge) and wisdom (tested intelligence). There are a number of unanswered questions: Should the definition of public health surveillance be extended from the dissemination of information to also include the dissemination of packets of actionable knowledge (intelligence) to decision-makers? Should there be an overlapping collaboration period when surveillance professionals work with decision-makers to fully understand the meaning of the information and knowledge from surveillance? Should surveillance be extended to include the monitoring and evaluation of policies and actions arising from information gained from surveillance and to guarantee that actions are promptly and properly planned and implemented (surveillance of surveillance, policy surveillance and policing the policies) (19, 20)? Are our public health surveillance and policy communities prepared to jointly confront the new challenges arising from the public health data-to-action continuum?

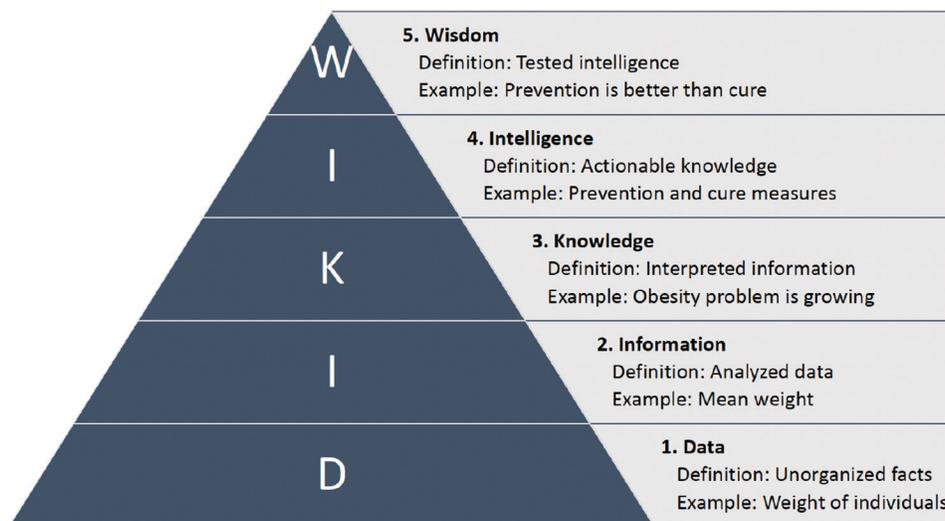
**TABLE 1. Comparison of two popular definitions of public health surveillance, 2023**

Description	Definition	
	World Health Organization (11)	US Centers for Disease Control and Prevention (12)
Characteristics	1. Continuous 2. Systematic	1. Ongoing 2. Systematic
Steps	1. Collection 2. Orderly consolidation and 3. Evaluation of pertinent data 4. With prompt dissemination of results to those who need to know, particularly those who are in a position to take action	1. Collection 2. Analysis and 3. Interpretation of health-related data 4. Essential to planning, implementation and evaluation of public health practice

Source: Table developed by the authors based on the cited references.

## INTEGRATING INTELLIGENCE AND WISDOM INTO SURVEILLANCE

The topic discussed in this article is both important and interesting. Its central idea presents a huge opportunity for changing the use of the public health surveillance information paradigm. The article conceptually addresses a relevant topic concerning the definition of public health surveillance, an essential component in consolidating information for decision-making in public health. As long-time public health surveillance professionals and researchers, the authors have seen the disconnect between information production (usually by scientists) and information

**FIGURE 1. Enhanced definitions of data, information, knowledge, intelligence and wisdom (DIKIW) for the DIKIW Conceptual Framework (1)**

**Source:** Figure developed by the authors based on information from various sources (1, 2) and the authors' enhancements of the conceptual framework.

use (usually by policy-makers) (18). It is time to further narrow the gap between science and policy and strengthen the bridge between data and action.

The proposed expansion of the current definition of surveillance beyond information dissemination will have impacts on and relevance to public health surveillance in all WHO Regions. But for several reasons we chose to initiate this discussion in the Region of the Americas. First, the authors have particular experience and expertise in surveillance in this Region (in Canada, Colombia and the United States of America). Second, we have access to members of a regional network of public health surveillance professionals, known as the Americas' Network for Chronic Disease Surveillance (AMNET) (19). AMNET includes members from all 35 Member States of the Pan-American Health Organization (PAHO). Third, we have plans to further investigate the topic by asking AMNET members about early initiatives and examples from their countries of formulating surveillance intelligence (actionable knowledge) based on surveillance information. This will be a useful resource to help build the continuum from data to information to action. For example, when the surveillance report on health-adjusted life expectancy in Canada was published in 2012 (21), the steering committee of the Public Health Agency of Canada organized several face-to-face meetings between the scientists who produced the 85-page report and high-ranking government officials. Together, they then formulated 48 actionable items. Furthermore, we also plan to determine whether AMNET members know of any initiatives by governments or universities in their country that focus on public health literacy training in knowledge management being delivered en masse to targeted professionals. A lack of education and training in public health literacy has been identified as an area for improvement in health surveillance globally (20) and in Brazil (22). Fourth, PAHO, as the world's oldest international public health agency, has been known for its support for new public health concepts and practices, such as an innovative method for prioritizing health programs in the Region of the Americas (23).

While advocating for efforts involving collaboration between science and policy-making in surveillance, we must be careful to acknowledge differences in the goals, attitudes toward information and career paths of these two groups of professionals, and also acknowledge the promoters of and barriers to collaboration (18). The concept of incorporating decision-making within surveillance could raise issues in public health that go beyond its definition. Within health care systems, there are functional structures that separate surveillance from decision-making for several important reasons. The first is that public health decisions are not only technical but they also involve politically relevant aspects across society. This does not create a contradiction between surveillance and decision-making; rather, it highlights the fact that decision-makers may distance themselves from surveillance results, leading to decisions being mitigated, deferred or even made that are contrary to the evidence due to inherent weaknesses in the evidence generated from surveillance and the information available. Second, the institutional structure in many countries separates those that conduct surveillance (typically a public health agency) from those that make decisions (such as ministries of health). This raises a clear and necessary distinction between public health surveillance and governance. Expanding surveillance to incorporate decision-making would mean replacing the entire field of public health, omitting the interdisciplinary aspects and social determinants that generate evidence crucial for decision-making but that are not inherently included in public health surveillance. This is a complex issue that is not easy to resolve because policies are not based only on scientific evidence but also on other things, such as values, emotions and the wishes of interest groups (18). In other words, surveillance and policy actions do not map one to one.

It could be argued that public health surveillance already includes a significant intelligence component that has the aim of not only generating information but also consolidating the necessary and sufficient evidence for decision-making by the

technical and political agents responsible for it. The modern concept of surveillance applied in most countries includes field epidemiology, verbal autopsies and genomic research, which are components of intelligence development applied in surveillance. However, we feel that the current definitions of surveillance still miss the intelligence component (actionable knowledge). There is a need to formally recognize and incorporate intelligence and actions, front and center, in the definition and scope of surveillance.

Public health surveillance has become highly developed over the centuries and perfected its front end functions (ongoing, systematic collection and analysis of data) (9). Data are now meticulously collected and then elegantly analyzed. However, the back end (interpretation of data with timely dissemination of information to those who need it) still has room for improvement (24). Starting with interpretation, the process becomes somewhat blurred. Interpretation is not a task that can be completed solely by surveillance professionals (scientists) based on collected data, and it requires other inputs, such as from policy-makers (18). Information dissemination still mainly uses population-based, one-size-fits-all printed or online brochures directed to the public, and memos, one-pagers and reports directed to policy-makers. We feel that more work is required to strengthen the back end of surveillance, especially in terms of developing personalized information dissemination (25). We also feel it is time to further extend the back end functions to include new components, such as generating surveillance information that leads to public health actions (data to action) and monitoring the success of surveillance systems (surveillance of surveillance) and the success of policies and actions (policy surveillance) (19, 20). We also need to explore new frontiers in public health surveillance (24). Within the framework of DIKIW, it is possible that future surveillance could incorporate the wisdom component (tested intelligence) – that is, the knowledge gained from experiences and acquired over time – that can be passed from one generation to another. In this regard, wisdom or lessons learned from public health research and practice during the COVID-19 pandemic should be able to be passed on to another pandemic decades or centuries later. Wisdom avoids the need to collect data from scratch again and to reinvent the wheel.

Our article has made major contributions to the DIKW and DIKIW conceptual frameworks in knowledge management. First, we propose a standard, consistent, simple and short definition for each level. For example, information is defined as “analyzed data” (Figure 1). Second, the two-word definition includes an adjective plus the name of the previous level. This allows for direct comparisons and identification of the differences between levels. For example, intelligence, which is the level after knowledge, is defined as “actionable knowledge” (Figure 1). Third, in our review of previous publications on DIKW and DIKIW, we found widespread errors and inconsistencies in the definitions. These previous definitions incorporate major errors by mixing up “a thing” with “a human quality” and, therefore, the pyramids are built based on apples and oranges. As a result, the levels of the conceptual framework cannot be compared. For example, data (facts collected, such as words, numbers, images, video, audio) and information (things learned and given meaning) are always things. But from knowledge to wisdom, both things and definitions of human qualities have been used: for example, knowledge (things – things

known – or a human quality – the ability to understand and act), intelligence (things – information of military or political value – or a human quality – the ability to apply knowledge) and wisdom (things – the accumulated body of knowledge – or a human quality – the quality of being wise, having experience and good judgment). This is confusing. In our enhanced DIKIW model, to ensure relevance to public health surveillance, we have standardized all definitions based on things (Figure 1). No human quality is involved.

This article focuses on public health surveillance, but our enhanced DIKIW model can be used to look into other public health areas, such as promoting healthy habits or funding high-cost medicines. Redefining surveillance provides an opportunity to clarify a number of concepts that are often unclear (public health surveillance, health situation monitoring and epidemiological surveillance) (26). They may each require a different definition. Also, to modernize the definition of surveillance it will be necessary to look into the connections between health domains and different interactions among all living and non-living things. One example is intersectoral collaboration, such as collaboration between public health and clinical medicine (27). There are so many intersectoral issues that arise from public health issues. Another key element for further work is the role of different forms of evidence in the DIKIW framework, such as evaluation, evidence syntheses and qualitative insights. Integrating the different types of evidence to address a specific concern is a key issue. Another pertinent issue for further work is to determine whether the solution might be to encourage surveillance experts to be public health decision-makers or to include knowledge translation specialists as members of decision-making bodies. The literature on knowledge translation has long advocated for the role of evidence intermediaries (entities or individuals that work in between information producers and decision-makers) (28).

In conclusion, we recommend that the scope of public health surveillance should go beyond information dissemination. It should ensure that the information obtained by a surveillance system will include not just knowledge but also actionable knowledge (intelligence). Surveillance systems should be expanded to monitor and evaluate responses and actions. Surveillance experts – who are responsible for collecting, analyzing and interpreting public health data and publishing reports – should have an obligation and a mandate to assist policy-makers in making evidence-informed decisions. Better still, surveillance experts should be encouraged to become policy-makers themselves. Public health literacy – from data to knowledge to wisdom – should be incorporated into training curricula for all public health professionals. Developing a new model of and definition for a more accurate and updated public health surveillance framework should be a starting point.

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## Vigilancia de salud pública y el paradigma de datos, información, conocimiento, inteligencia y sabiduría

### RESUMEN

En este artículo se señalan las deficiencias de las definiciones actuales de la vigilancia de salud pública, que incluyen la recopilación, el análisis, la interpretación y la difusión de los datos, pero no las medidas de salud pública. El control de un problema de salud pública de interés exige una respuesta de salud pública que vaya más allá de la difusión de información. No es deseable que la salud pública esté dividida por un lado en procesos de generación de datos (vigilancia de salud pública) y por otro en procesos de uso de datos (respuesta de salud pública), gestionados por dos grupos diferentes (expertos en vigilancia y responsables de la formulación de políticas). Ha llegado el momento de replantear la necesidad de modernizar la definición de la vigilancia de salud pública tomando como referencia el modelo mejorado de Datos, Información, Conocimiento, Inteligencia y Sabiduría de los autores. Entre las recomendaciones que se proponen se encuentran las de ampliar el alcance de la vigilancia de salud pública más allá de la difusión de información para que incluya también el conocimiento aplicable (inteligencia); instar a los expertos en vigilancia a que presten ayuda a los responsables de la formulación de políticas en la toma de decisiones basadas en la evidencia; alentar a los expertos en vigilancia a que se conviertan en responsables de la formulación de políticas; e incorporar la formación en conocimientos básicos de salud pública (desde los datos hasta los conocimientos y la sabiduría) en los planes de estudio de todos los profesionales de la salud pública. Un buen punto de partida será trabajar en la modernización del alcance y la definición de la vigilancia de salud pública.

### Palabras clave

Vigilancia en salud pública; recolección de datos; gestión de la información en salud; gestión de la salud poblacional; alfabetización en salud; aprendizaje del sistema de salud; inteligencia.

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## Vigilância em saúde pública e o paradigma de dados, informações, conhecimento, inteligência e sabedoria

### RESUMO

Este artigo aponta deficiências nas definições atuais de vigilância em saúde pública, que incluem coleta, análise, interpretação e disseminação de dados, mas não ações de saúde pública. O controle de um problema preocupante de saúde pública exige uma resposta de saúde pública que vá além da disseminação de informações. A saúde pública não deve ser dividida em processos de geração de dados (vigilância em saúde pública) e processos de uso de dados (resposta de saúde pública) gerenciados por dois grupos distintos (especialistas em vigilância e formuladores de políticas). É hora de repensar a necessidade de modernizar a definição de vigilância em saúde pública, inspirada no modelo aprimorado de Dados, Informações, Conhecimento, Inteligência e Sabedoria dos autores. Nossas recomendações incluem: expansão do escopo da vigilância em saúde pública para além da disseminação de informações, de modo a abranger conhecimentos acionáveis (inteligência); obrigatoriedade de que os especialistas em vigilância auxiliem os formuladores de políticas na tomada de decisões baseadas em evidências; incentivo para que os especialistas em vigilância se tornem formuladores de políticas; e incorporação de capacitação em letramento em saúde pública (partindo dos dados para o conhecimento e em seguida para a sabedoria) nos currículos de todos os profissionais de saúde pública. O trabalho de modernizar o escopo e a definição de vigilância em saúde pública será um bom ponto de partida.

### Palavras-chave

Vigilância em saúde pública; coleta de dados; gestão da informação em saúde; gestão da saúde da população; letramento em saúde; sistema de aprendizagem em saúde; inteligência.

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