Review

Drawing on the Development Experiences of Infectious Disease Surveillance Systems Around the World

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ABSTRACT

High-quality infectious disease surveillance systems are foundational to infectious disease prevention and control. Current major infectious disease surveillance systems globally can be categorized as either indicator-based, which are more specific, or event-based, which are more timely. Modern surveillance systems commonly utilize multi-source data, strengthened information sharing, advanced technology, and improved early warning accuracy and sensitivity. International experience may provide valuable insights for China. China's existing infectious disease surveillance systems require urgent enhancements to monitor emerging infectious diseases and improve the integration and learning capabilities of early warning models. Methods such as establishing multi-stage surveillance systems, promoting cross-sectoral and cross-provincial data sharing, applying advanced technologies like artificial intelligence, and cultivating professional talent should be adopted to enhance the development of intelligent and multipoint-triggered infectious disease surveillance systems in China.

Throughout history, infectious diseases have caused enormous loss of life and social distress, and despite modern scientific and technological advances, they remain an ongoing threat. The emergence and re-emergence of infectious diseases serve as reminders of the need for constant vigilance. High-quality surveillance systems are crucial for the effective prevention and control of infectious diseases. By collecting and analyzing epidemic data, these systems detect infectious disease trends and provide early warnings of potential outbreaks, enabling authorities to take swift action and reduce the risk of disease transmission.

China implemented the National Notifiable Infectious Diseases Reporting Information System (NIDRIS) in 2004 to enable nationwide direct reporting of infectious diseases. In 2008, the China Infectious Diseases Automated-alert and Response System (CIDARS) launched, creating an automatic warning model based on NIDRIS data (*1*). These systems have helped address China's infectious disease surveillance and early warning challenges. However, over time, NIDRIS and CIDARS have encountered problems such as delayed warning checkpoints, limited information sources, and technologies in need of improvement (*2*). The inauguration of the National Bureau of Disease Control and Prevention in 2021 signified the start of reform for China's disease prevention and control system. Infectious disease surveillance, a pivotal responsibility of the CDC, is in urgent need of improvement. As President Xi Jinping emphasized, enhancing monitoring and early warning capabilities should be a top priority for a sound public health system. China requires intelligent and multi-point-triggered surveillance systems, which generally refer to advanced systems that leverage technologies such as big data, cloud computing, the Internet of Things, and artificial intelligence (AI) to automatically collect data, synthesize results, and issue early warnings from multiple critical nodes in the infectious disease lifecycle. Such systems also incorporate public opinion data from media and social networks, along with other sociologically relevant information about disease emergence, to improve the sensitivity, accuracy, and timeliness of early warnings, thereby reducing human error and oversight (*2*).

China can benefit from international experience in developing surveillance systems. This article reviews global experience with infectious disease surveillance systems to understand potential improvements for China's national surveillance system, aiming to provide insights for constructing intelligent, multipoint-triggered infectious disease surveillance systems in China.

OVERVIEW OF SURVEILLANCE SYSTEMS GLOBALLY

Infectious disease surveillance can be defined as continuously and systematically collecting information on infectious diseases and related factors and dynamically analyzing the temporal, spatial, and population distribution of infectious diseases to understand the current status and trends of infectious diseases and provide guidance for preventive and control measures (*3*). The main components of an infectious disease surveillance system include data collection, data management, data analysis, investigation, and reporting (*4*). Early warning identifies abnormal signals from surveillance data and then performs alert management, which involves managing and sorting these signals to ensure effective responses. Together, surveillance, early warning, alert management, and response form a comprehensive process that is critical to the timely detection and opportune management of infectious disease threats (*5*).

We searched PubMed, Web of Science, and China National Knowledge Infrastructure using the following search terms: (infectious disease OR communicable disease) AND (surveillance OR monitoring OR early warning) AND system. From the retrieved articles, we extracted specific information about each surveillance system, including system name, website, system type, country or region, year started, area of service, data sources, data access, functions, and features. We selected and summarized infectious disease surveillance systems from leading countries or regions, including the United States and Canada for North America, the European Union for Europe, China and Japan for Asia, and Australia for Oceania. According to the European CDC's methodological framework for epidemiological intelligence, infectious disease surveillance systems can be classified as indicator-based and event-based (*6*). Indicator-based systems collect structured data from routine surveillance like case numbers, morbidity, mortality, laboratory test results, and consumption of specific drugs. Event-based systems collect unstructured data from any formal or informal source and are mainly used in web-based surveillance systems such as the Program for Monitoring Emerging Diseases (ProMED) Mail, the Global Public Health Intelligence Network (GPHIN), and HealthMap (*7*–*8*).

Indicator-Based Surveillance Systems

Indicator-based surveillance systems are technologically mature and rely on passive reporting by healthcare organizations (Table 1). For instance, the United States' National Notifiable Diseases Surveillance System (NNDSS) (*9*), China's NIDRIS and CIDARS, and the European Surveillance System (TESSy) (*10*) are used to monitor cases of notifiable infectious diseases. The United States' Electronic Laboratory Reporting (ELR) systems and Japan's Infectious Agents Surveillance Report (IASR) monitor laboratory testing information (*11*). Before microbiological confirmation, syndromic surveillance collects and analyzes routine health-related data on symptoms and clinical signs, often from emergency departments and other healthcare settings (*12*–*13*). In the United States, the National Syndromic Surveillance Program (NSSP) has been instrumental in detecting and monitoring health threats by aggregating data from over 6,500 healthcare facilities across the country (*14*). In England, national real-time syndromic surveillance systems have been developed using data from telemedicine triage systems, general practice, and emergency departments to support early detection of seasonal influenza and situational awareness during public events (*15*).

In recent years, wastewater surveillance has emerged as a critical component of indicator-based surveillance systems. Klapsa and colleagues reported the detection of poliovirus isolates related to the serotype 2 Sabin vaccine strain in London sewage samples, demonstrating the potential of wastewater surveillance in identifying community transmission and genetic evolution of pathogens (*16*). Similarly, several countries and regions, including the Netherlands, Australia, France, and United States, have implemented wastewater surveillance programs to monitor for SARS-CoV-2 and other pathogens (*17*–*18*), providing timely data on disease prevalence and transmission dynamics. In addition, specific early warning components such as the European Antimicrobial Resistance Surveillance Network (EARS-Net) (*19*), prescription surveillance in Japan (*20*), and the Over-The-Counter (OTC) medication sales monitoring in the United States provide parallel data streams that are synergistically integrated into broader surveillance frameworks (*21*). The EARS-Net tracks antimicrobial resistance patterns as part of the European disease and laboratory networks. Meanwhile, OTC medication sales monitoring and prescription surveillance analyze sales data for specific drugs as an

TABLE 1. Major indicator-based surveillance systems.

System (website)	Country/ region (year started)	Data sources	Data access	Functions	Features
NIDRIS (*1*)	China (2004)	Medical institutions	Restricted	The healthcare departments review infectious disease information reported by medical institutions and then report to NIDRIS. It monitors individual cases, diagnoses, and epidemiological information on 39 infectious diseases.	Case surveillance. Multisectoral cooperation.
NNDSS (https://www.cdc.gov/nndss/index.html) (*9*)	United States (Before 1990)	Health departments, healthcare providers, laboratories, and hospitals	Public	The health departments work with healthcare providers, laboratories, hospitals, and other partners to obtain information. Surveillance of notifiable disease cases was carried out in about 3,000 health institutions.	Case surveillance. Multi-source data and multisectoral cooperation.
TESSy (https://www.ecdc.europa.eu/en/publications-data/european-surveillance-system-tessy) (*10*)	Europe (2008)	European Union member states	Restricted	Surveillance of notifiable infectious disease cases.	Case surveillance. International cooperation.
CIDARS (*1*)	China (2008)	Data reported in NIDRIS	Restricted	Case data extraction, early warning analysis, and signal push daily. It analyzes the situation of 39 infectious diseases and provides early warning to provincial and municipal CDCs.	Case surveillance
ELR (https://www.cdc.gov/elr/index.html) (*11*)	United States (2001)	Laboratories	Restricted	ELRs are transmitted from the laboratory to public health departments, health care systems, and CDCs for further public health action. It monitors laboratory testing information.	Laboratory surveillance. Multisectoral cooperation.
IASR (https://www.niid.go.jp/niid/ja/iasr.html)	Japan (1980)	Local public health laboratories, public health centers, and quarantine stations throughout the country.	Public	Surveillance of laboratory testing information, including pathogen differential diagnosis, genetic testing, and drug resistance test results.	Laboratory surveillance. Multi-source data and multisectoral cooperation.
NSSP (https://www.cdc.gov/nssp/php/about/index.html) (*14*)	United States (2003)	Emergency department, laboratories, medical centers, weather service data	Restricted	By tracking the symptoms of patients in the emergency department and other environments in almost real-time, a timely system is provided for public health officials to detect, understand, and monitor health threats to determine whether they need to be addressed.	Syndromic surveillance. Multi-source data and multisectoral cooperation.
EARS-Net (https://www.ecdc.europa.eu/en/about-us/networks/disease-networks-and-laboratory-networks/ears-net-data) (*19*)	Europe (1998)	National antimicrobial resistance surveillance initiatives, laboratory networks	Public	Collect comparable, representative, and accurate data on antimicrobial resistance, analyze the spatiotemporal trends of antimicrobial resistance in Europe, and provide support for policy decision-making	Laboratory surveillance. International cooperation.
Prescription surveillance (*20*)	Japan (2009)	Pharmacies	Restricted	Report the estimated numbers of influenza and varicella patients and people prescribed certain drugs.	Surveillance of drug purchases.

Abbreviation: NIDRIS=National Notifiable Infectious Diseases Reporting Information System; NNDSS=National Notifiable Diseases Surveillance System; TESSy=The European Surveillance System; CIDARS=China Infectious Diseases Automated-Alert and Response System; ELR=Electronic Laboratory Reporting system; IASR=Infectious Agents Surveillance Report; NSSP=National Syndromic Surveillance Program; EARS-Net=European Antimicrobial Resistance Surveillance Network.

important component of syndromic surveillance to identify trends that may indicate disease transmission. Most of these systems involve multisectoral collaboration for data validation or further public health action.

Indicator-based surveillance systems are characterized by their specificity, as they rely on physician-diagnosed and laboratory-confirmed data, utilizing pre-defined case definitions and/or laboratory testing to ensure a clear and consistent identification of cases. Typically, indicator-based surveillance reports are compiled on a weekly or monthly basis from primary public health units, which ensures a more complete and specific dataset, albeit at the cost of timeliness. This reporting frequency may lead to reporting delays and information omissions, which in turn can result in lagging or missed warnings, particularly for emerging infectious diseases where the case definitions may not yet be well-established or the disease may present with atypical symptoms.

Event-Based Surveillance Systems

The prevalent event-based surveillance systems are primarily web-based, capturing all unstructured data that appears on the internet, including social media posts, search inquiries, e-commerce trends, and wearable device records (*22*). Event-based surveillance systems can be further categorized into news aggregators, automatic and moderated systems (*7–8*). News aggregators aggregate web content by location or topic into one platform for convenient access, such as Influenzanet (*23*), FluTracking (*24*), and Google Flu Trends (*25*), the last of which is no longer updated. Automatic systems add a series of analytic steps to news aggregators, as seen in the Semantic Processing and Integration of Distributed Electronic Resources for Epidemiology (EpiSPIDER) (*26*), HealthMap (*27*), BioCaster (*28*), EPIWATCH (*29*), and the Medical Information System (MedISys) (*30*). Moderated systems involve the screening of information by public health professionals before reports release, thus exhibiting fewer false positives compared to news aggregators and automatic systems, exemplified by GPHIN (*31*), ProMED-mail (*32*), and Argus (*33*). A summary of the characteristics of the ten event-based surveillance systems is presented in Table 2.

Web-based surveillance systems commonly use multilingual and multi-source data to monitor vast amounts of online information on infectious diseases. For instance, HealthMap, an automatic system operational since 2006, monitors online information on emerging diseases in nine languages, utilizing data from sources like Baidu, EuroSurveillance, Google, and WHO, among others (*27*). MedISys, operating within the European Union since 2004, collects public health reports in 32 languages from global internet sources, providing summaries on various diseases (*30*). Argus, a moderated system, collects information from media sources in 40 native languages and uses Bayesian analysis tools for filtering and selection, focusing on biological events posing global health threats (*33*). Some systems use advanced AI technology to drive data analysis. For example, BioCaster, relaunched in 2021, utilizes deep learning and natural language processing models to analyze structurally complex data from thousands of news reports daily, enabling real-time detection and interactive visualization of outbreak reports (*34*). EPIWATCH employs AI to scan open-source data, detecting early warnings of infectious disease outbreaks since 2016, with continuous enhancements through machine learning (*29*). GPHIN implements a machine learning classifier to score the relevance of reports, distinguishing outbreak-related stories from background noise, with high-scoring articles published immediately and low-scoring ones suppressed, while medium-relevance articles are reviewed by analysts (*35*). The integration of advanced technologies enables these systems to demonstrate significant advantages in capturing early abnormal signals, thereby facilitating the timely detection and management of public health threats. Influenzanet and FluTracking are two representative participatory surveillance platforms that collect data from volunteers at multiple stages of symptoms, absence from school or work, medication, medical consultations, and vaccinations. Participatory surveillance improves previous health surveillance systems by involving the public in the construction of epidemiologic scenarios (*36–37*).

Event-based surveillance systems enable timely surveillance and early warning by facilitating immediate reporting and rapid investigation of diseases of public health significance. Event-based surveillance serves as a complementary early warning mechanism for emerging infectious diseases, emphasizing the importance of immediate reporting and management to ensure a swift response, which is also an essential feature that distinguishes it from indicator-based surveillance. For example, GPHIN has been recognized for its role in detecting early signals during public health emergencies, such as the SARS outbreak in 2003 and the initial reports of the Ebola outbreak in West Africa in 2014 (*38*). It is worth noting that GPHIN's contributions are part of a broader array of surveillance and intelligence efforts, whose alerts are based on a combination of local accounts and media reports that collectively contribute to the early identification of potential outbreaks. However, the information obtained by event-based surveillance systems is not fully verified by public health professionals, so the reliability of the information they monitor cannot be guaranteed. When used for early warning, their low signal-to-noise ratio might drain considerable public health resources (*5*). Hence,

TABLE 2. Major event-based surveillance systems.

System (website)	Type	Country/ region (year started)	Area of Service	Data sources	Data access	Functions	Features
HealthMap (https://healthmap.org/about/) (*27*)	Automatic system	United States (2006)	Worldwide	Baidu, EuroSurveillance, Google, HealthMap Community News Reports, WOAH, ProMED, User Eyewitness Reports, and WHO	Public	Online information on emerging diseases is monitored in nine languages, providing real-time surveillance of public health threats based on informal data sources	Multi-source data and multilanguage
EpiSPIDER (http://www.epispider.org/) (*26*)	Automatic system	United States (2006)	North America, Europe, Australia, Asia	Daylife, Google, Humanitarian News, Moreover, ProMED, Twitter, and WHO	Public	Integrate information collected from online media and informal surveillance systems in English to monitor outbreaks of infectious diseases	Multi-source data
MedISys (http://medusa.jrc.it) (*30*)	Automatic system	Europe (2004)	European Union	Global internet resources	Restricted /Limited to European Union member states	Collect public health reports in 32 languages from global internet sources and compile summaries of information on various diseases	Multi-source data and multilanguage
Argus (*33*)	Moderated system	United States (2004)	Worldwide	Printed newspapers, electronic media, Internet-based newsletters and blogs, WHO, and WOAH	Restricted	Information is collected from media sources in 40 native languages, and Bayesian analysis tools are used to select and filter the information. It aims to monitor biological events that may pose a global health threat to humans, plants and animals	Multi-source data and multilanguage
ProMED-mail (https://promedmail.org/) (*32*)	Moderated system	United States (1994)	Worldwide	Media reports, official reports, online summaries, and local observers	Public	A transparent, non-political, open to all, free e-mail list for identifying emerging and re-emerging infectious diseases and unusual health toxin-related events	Multi-source data and multilanguage
BioCaster (http://biocaster.nii.ac.jp) (*34*)	Automatic system	Japan (2006)	Priority to Asia-Pacific region	EurekAlert!, European Media Monitor Alerts, Google, the CDC's Morbidity and Mortality Weekly Report, MeltWater, WOAH, ProMED, Reuters, WHO and Vetsweb	Public	An ontology-based text mining system that detects and tracks the distribution of infectious diseases from the internet in eight languages. A quantum leap in real-time detection of disease outbreaks has been achieved through the integration of artificial intelligence technology	Multi-source data, multilanguage, and advanced technology
EPIWATCH (https://www.epiwatch.org/) (*29*)	Automatic system	Australia (2016)	Worldwide	Media coverage, press releases, official reports, and social media	Public	An open-source epidemic observation station based on artificial intelligence that searches global internet resources in 52 languages to promptly detect infectious disease outbreaks. The system is enhanced by the integration of artificial intelligence and machine learning technologies	Multi-source data, multilanguage, and advanced technology
GPHIN (https://gphin.canada.ca/) (*31*)	Moderated system	Canada (1997)	Worldwide	News service items, ProMED-mail, electronic discussion groups, and selected websites	Restricted /Subscription	Surveillance of global media messages in nine languages to detect and track major public health events and provide real-time, early warning based on the international internet sources. The latest generation of GPHIN integrates machine learning technology (*35*)	Multi-source data, multilanguage, and advanced technology

Continued

System (website)	Type	Country/ region (year started)	Area of Service	Data sources	Data access	Functions	Features
Influenzanet (https://influenzanet.info/explore-data) (*23*)	News aggregator	Europe (2003)	The Netherlands, Belgium, Portugal, Italy, the UK, France, Sweden, Spain, Ireland, Denmark, and Switzerland	Online survey	Public	Influenza-like illness (ILI) incidence in Europe was monitored by screening the ILI questionnaire completed by volunteers. In the questionnaire, participants are asked to report information on symptoms, date of onset, absence from school or work, medication, and medical consultations and outcomes	Participatory surveillance and multi-stage surveillance
FluTracking (https://info.flutracking.net/) (*24*)	News aggregator	Australia (2006)	Australia	Online survey	Public	A participatory surveillance system to monitor the spread and severity of ILI in Australia by investigating symptoms (cough, fever, and sore throat), time off work or normal duties, influenza vaccination status, influenza laboratory testing, and health-seeking behaviors	Participatory surveillance and multi-stage surveillance

Abbreviation: WOAH=World Organization for Animal Health; ProMED=Program for Monitoring Emerging Diseases; WHO=World Health Organization; EpiSPIDER=Semantic Processing and Integration of Distributed Electronic Resources for Epidemiology; MedISys=Medical Information System; GPHIN=Global Public Health Intelligence Network

improving data quality from event-based surveillance should be an ongoing endeavor.

Commonalities Between Surveillance Systems

Concerning data collection, first, the data are multi-sourced. Although surveillance data were initially derived from clinical diagnoses and laboratory tests, with the emergence and use of big data technology, the data sources have expanded to include symptoms, human behavior, and social activities, which have diversified the types of data available for infectious disease surveillance. Second, information sharing has been enhanced through transnational cooperation, which enables faster responses to infectious disease threats by fostering collaboration among international organizations, government agencies, and non-governmental organizations, and through multidisciplinary collaboration, in which experts from various fields work together to advance infectious disease surveillance systems.

At the data analysis stage, modern surveillance systems have embraced a range of sophisticated methodologies to systematically process and interpret the vast and diverse datasets they collect. These methods include high-throughput analysis, which allows for the rapid examination of large volumes of data (*39*); aberration detection techniques, such as control charts and linear regressions, which identify deviations from expected patterns that may indicate the onset of an outbreak (*40*); and spatiotemporal clustering algorithms, which help in pinpointing the geographic and temporal distributions of cases (*41*). For example, the CDC in the United States uses the Early Aberration Reporting System to detect anomalies in disease surveillance data (*42*). Likewise, public health institutes in European countries use the Farrington algorithm, a quasi-Poisson regression model, to monitor disease incidence across member states (*43*). These traditional methods remain foundational in public health surveillance, but there has been a notable increase in the adoption of more sophisticated techniques, such as machine learning and Bayesian frameworks, particularly for multivariate datasets. For example, EPIWATCH's ability to provide early outbreak signals has been enhanced by AI and machine learning (*29*). Moreover, AI can be used to develop predictive models that can forecast the spread of infectious diseases based on various factors, including environmental conditions, population movements, and historical outbreak data. These algorithms learn from patterns and trends in the data, improving their accuracy over time and providing valuable insights that complement traditional surveillance data.

In terms of outputs, early warning sensitivity and accuracy are constantly improving. Systems based on online media can serve as a valuable complement to official surveillance and early warning systems, offering more timely warnings and improved sensitivity. Moreover, despite the heterogeneous nature of internet surveillance information, technological advances can significantly reduce data noise, and thus, the accuracy of early warning is also rising. This evolution ensures that public health responses are increasingly informed by precise and timely data, enabling a more effective containment of infectious disease threats.

DISCUSSION AND FUTURE DIRECTIONS

International experience in constructing infectious disease surveillance systems has provided beneficial insights for China. The NIDRIS and CIDARS systems currently used in China are based on analyses of clinically confirmed cases. Although highly accurate, this approach often results in a significant lag. Surveillance and early warning platforms can be established at multiple stages before the diagnosis of infectious disease patients, including risk factors, symptoms, medication purchases, absenteeism from work or school, and medical consultations. In this case, warning signals can be released earlier, which is critical for the early management of infectious diseases (*2*). Some syndromic surveillance systems have been established in China, but they only operate on a pilot basis in certain regions (*44–45*). Establishing participatory syndromic surveillance systems at the national level could enhance surveillance activities. For example, collecting crowdsourced data on influenza-like illnesses to track respiratory viruses promptly. Event-based internet surveillance systems complement NIDRIS and CIDARS by highlighting potentially contagious cases that have not been clinically confirmed. Carefully screening and integrating valid information can better address potential risks. Recent scientific recommendations, such as the 7-1-7 metric, have been proposed to quantify outbreak surveillance, notification, and response performance. The 7-1-7 framework measures the timeliness of surveillance (target of ≤7 days from emergence), notification (target of ≤1 day from detection), and completion of seven early response activities (target of ≤7 days from notification) (*46*). Implementing such metrics may help identify bottlenecks and enablers within the system, thereby facilitating targeted improvements and prioritizing national planning for early outbreak management.

Second, NIDRIS and CIDARS primarily collect data from healthcare institutions, and data exchange between different sectors is limited. It is necessary to consider utilizing data from sources such as media, schools, workplaces, pharmacies, laboratories, and customs. Enhanced multisectoral cooperation and information-sharing are crucial for obtaining comprehensive information on disease and health-related events (*2*). Furthermore, China should exchange information on infectious diseases with other countries. The WHO established a new global hub for pandemic and epidemic intelligence in Berlin, Germany (*47*), to enhance data sharing and international cooperation for the early detection of potential pandemics. This hub, in collaboration with the EIOS initiative, supports a unified, all-hazards, One Health approach to the early detection, verification, assessment, and communication of public health threats using publicly available information (*48*). EIOS facilitates global, multisectoral collaboration, supporting countries and other stakeholders in addressing future pandemic and epidemic risks with improved access to data, enhanced analytical capacities, and improved tools and insights for decision-making. China should, as always, actively participate in global infectious disease early warning efforts, leveraging initiatives like EIOS to strengthen its contribution to global health security.

Finally, the early warning model of China's infectious disease surveillance platform, represented by CIDARS, is primarily based on the fixed-threshold detection method, temporal models, and spatial-temporal models (*49*). As technology advances, CIDARS should be updated to enhance its data integration and intelligent learning abilities to improve the effectiveness of early warnings (*2*). Modern, intelligent surveillance systems require AI algorithms to rapidly collect, efficiently process, and thoroughly analyze large-scale, multi-source data for timely and accurate outbreak warnings. Additionally, diverse data formats, including text, images, video, and audio, may necessitate the use of blockchain and multimodal technologies to consolidate them into a structured database, enabling collaborative management of heterogeneous data from various sources. However, the successful implementation of AI in surveillance systems also requires a skilled workforce with expertise in epidemiology, advanced data analysis, and system management. In China, a notable shortage of CDC professionals limits the improvement of infectious disease surveillance, management, and emergency response capabilities. Therefore, targeted training of professionals who can interpret AI outputs, conduct epidemiological investigations, and make informed decisions based on complex data is essential. On October 25, 2023, China established the National Data Bureau to coordinate data integration and promote the development of a digital China. The Bureau will accelerate digital technology innovations and assist in building intelligent surveillance systems while fostering the development of a highly skilled public health workforce to ensure the effective utilization of these advanced technologies.

The China CDC leadership has steadily strengthened the surveillance and early warning capacity of provincial CDCs. Intelligent, multipoint-triggered early warning models are being explored in several PLADs. Decentralizing early warning tasks to PLADs is a crucial strategic innovation that allows customization to regional factors, facilitating accurate monitoring and resource deployment. This decentralization is imperative because it enables efficient and timely detection, verification, investigation, and early response at a more localized level, further enhancing the national surveillance system's overall efficiency. However, differences in surveillance capacity among provincial CDCs may compromise the accuracy and comparability of results. Moreover, competition among provincial CDCs may hinder infectious disease data sharing, as infectious disease surveillance and early warning are linked to CDC performance evaluations. Therefore, information-sharing mechanisms across PLADs are needed to ensure accurate and complete data for timely infectious disease prevention.

The numerous practical challenges in constructing intelligent, multipoint-triggered surveillance systems must be recognized. For example, multi-point surveillance collects large quantities of user data, which inevitably carries the risk of leaking private information. Thus, technologies like decentralization and data encryption are necessary for privacy protection. Furthermore, a key challenge with event-based surveillance is distinguishing between true and false information. Therefore, information filtering and verification strategies are needed to determine the credibility of surveillance data.

CONCLUSION

In summary, China's current infectious disease surveillance systems should be upgraded to meet new-era requirements. According to the findings of this review, the term "multipoint-triggered" implies multi-source data, multi-stage monitoring, and multisectoral and multi-provincial cooperation. The term "intelligent" implies the application of advanced and learning-capable warning models and analysis techniques. Intelligent and multipoint-triggered infectious disease surveillance systems will significantly improve the timeliness and accuracy of early warnings and further strengthen China's ability to respond to public health emergencies.

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