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Research on the Optimization Path of Infectious Disease Monitoring System in Public Health Emergencies

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Abstract: After years of development, China's infectious disease monitoring system has formed a nationwide network with medical institutions as sentinel points, disease control institutions as the core, and information systems as the support. However, in public health emergencies, it still exposes problems such as insufficient monitoring sensitivity, uneven data quality, and inefficient cross-departmental collaboration. This article analyzes the current status of monitoring systems at home and abroad and proposes optimization paths from the perspectives of monitoring network construction, data capability improvement, and legalization construction. It aims to provide a theoretical reference for improving the ability of infectious disease monitoring, early warning, and emergency response.

Keywords: Infectious disease monitoring system; Public health emergencies; Optimization path; Cross-departmental collaboration

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1. Introduction

Since the founding of the People's Republic of China, the infectious disease monitoring system has developed and improved continuously, accumulating rich experience in responding to various infectious diseases. However, facing new challenges such as emerging and re-emerging infectious diseases, accelerated population mobility, and iterative monitoring technologies, the existing monitoring system still exposes problems such as insufficient sensitivity, poor data sharing, and lagging emergency response. At the same time, advanced practices in information integration, legal protection, and fine management in countries such as the United States, Japan, and Singapore provide important references for optimizing China's monitoring system. In this context, it is of great theoretical and practical significance to deeply analyze the current operating status of China's infectious disease monitoring system in public health emergencies, learn from international experience to explore optimization paths, and improve China's infectious disease prevention and control capabilities, and strengthen public health safety defenses.

2. Current status analysis of the infectious disease monitoring system in public health emergencies

2.1. Development history and current status of China's infectious disease monitoring system

In the early days of the founding of the People's Republic of China, infectious diseases such as plague and cholera posed severe threats. The "General Rules on Establishing an Infectious Disease Reporting System" was issued in 1950, marking the initial establishment of China's infectious disease monitoring system. Since then, with the development of the health industry, the reporting system has been continuously improved. After the reform and opening up, facing new challenges brought by population mobility, the "Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases" was promulgated in 1989, providing legal protection, strengthening the construction of disease control institutions, and introducing advanced monitoring technologies. In recent years, due to the attention of the Party Central Committee and the State Council, the Ministry of Health has formulated the "National Public Health Information System Construction Plan" and launched the Infectious Diseases and Public Health Emergencies Online Direct Reporting System since January 1, 2004. This has completely changed the traditional infectious disease reporting management model [1]. Currently, China has established a nationwide infectious disease monitoring network, forming a system with medical institutions as sentinel points, disease control institutions as the core, and information systems as the support. The monitoring of disease types has expanded to 40, and emerging technologies are widely used. Information sharing facilitates collaborative prevention and control. However, there are still problems such as weak grassroots monitoring, technical equipment needing improvement, and imperfect departmental information sharing mechanisms, which require further improvement.

2.2. Experience from the infectious disease monitoring systems of typical countries

The infectious disease monitoring system in the United States is characterized by a high degree of informatization and multi-sectoral collaboration. The Centers for Disease Control and Prevention (CDC) coordinates national efforts, while the National Electronic Disease Monitoring System integrates information from multiple departments to achieve real-time sharing and analysis. It also utilizes big data for early warning and actively participates in global monitoring cooperation. Japan excels in its comprehensive laws and efficient emergency response mechanisms. The Infectious Diseases Control Law clarifies the responsibilities of various parties, and the emergency command system can quickly respond to outbreaks. Japan also prioritizes public education, leads in the development and application of monitoring technology, and enhances early diagnosis capabilities [2]. Singapore is known for its precise management and intelligent applications. It collects comprehensive data through a dense network of monitoring sentinels and utilizes smart systems to analyze multi-source information. It develops targeted preparedness plans for different infectious diseases and has established information-sharing mechanisms with neighboring countries to address cross-border risks.

3. Problems with infectious disease monitoring systems during public health emergencies

3.1. Insufficient sensitivity and timeliness of monitoring

The current infectious disease monitoring system has significant shortcomings in sensitivity and timeliness. Some primary healthcare institutions face difficulties in identifying cases early due to a lack of professionals and outdated

detection equipment. For example, in remote mountainous areas, limited medical resources make it challenging for healthcare workers to accurately diagnose atypical symptoms of infectious diseases, leading to delayed case reporting. Additionally, the existing monitoring system relies heavily on active reporting by medical institutions. However, some private clinics and hospitals may conceal or omit reports to avoid trouble or damage to their reputation, preventing the timely detection of outbreaks [3]. Even when cases are reported promptly, information delays can occur during transmission from primary healthcare institutions to higher-level disease control departments due to complex processes and communication issues, missing critical opportunities for epidemic prevention and control.

3.2. Need to improve the accuracy and completeness of monitoring data

The quality of monitoring data directly affects the scientific decision-making process for infectious disease prevention and control. On the one hand, a lack of standardized training for medical staff when filling out infectious disease report cards can lead to incorrect or incomplete information. For instance, vagueness in key details such as patient age, gender, and onset time can affect the accuracy of subsequent data analysis [4]. On the other hand, differences in information systems used by various regions and medical institutions result in inconsistent data formats, leading to issues like data loss or mismatched information during data integration. Furthermore, diagnostic criteria for some infectious diseases have ambiguous areas, causing discrepancies in diagnoses among different doctors for the same case. This makes it difficult for reported data to accurately reflect the actual epidemic situation, interfering with accurate judgments about infectious disease trends.

3.3. Inadequate sharing and utilization of monitoring information

Infectious disease monitoring information involves multiple departments such as health, transportation, customs, and education. However, the current information sharing mechanism among these departments is not well-established, resulting in significant information barriers [5]. The health department holds case information, the transportation department possesses data on personnel mobility, and the customs department has health information on incoming and outgoing travelers. Nevertheless, effective integration of these data is challenging, making it difficult to form a comprehensive picture of epidemic prevention and control. Simultaneously, the utilization efficiency of monitoring information is low, with large amounts of data remaining at the basic statistical level and lacking deep analytical exploration [6]. For instance, there is insufficient utilization of big data technology to uncover potential patterns in the spread of infectious diseases from vast datasets, hindering the development of more forward-looking recommendations for epidemic prevention and control strategies.

3.4. Insufficient capabilities of the monitoring system to respond to emerging and re-emerging infectious diseases

With the acceleration of globalization and changes in the ecological environment, emerging and re-emerging infectious diseases continue to emerge, posing serious challenges to the existing monitoring system. Currently, the early warning mechanism of the monitoring system is mainly targeted at known infectious diseases, and its ability to identify and warn of emerging infectious diseases is relatively weak. Due to the lack of detection technology and means for unknown pathogens, it is often difficult to quickly diagnose emerging infectious diseases in their early stages. In addition, for some infectious diseases that were once controlled but have re-emerged, the monitoring system has failed to adjust its monitoring focus and strategy promptly, resulting in a delayed response. Furthermore, the existing monitoring system

suffers from insufficient scientific research and innovation capabilities, and progress in key areas such as vaccine research and development and drug screening is slow, making it difficult to quickly form effective prevention and control measures.

3.5. Insufficient legal construction of the monitoring system and mechanisms

Although China has issued a series of laws and regulations related to the prevention and control of infectious diseases, there are still loopholes in the legalization of the infectious disease monitoring system and mechanisms. Existing laws and regulations do not provide detailed provisions on the rights and obligations of each entity involved in monitoring work. In practical operations, some units and individuals do not fully understand the importance of monitoring work and treat monitoring tasks negatively, but there is a lack of clear legal provisions for accountability [7]. Meanwhile, with the development of information technology, the security and privacy protection of infectious disease monitoring data have become increasingly prominent issues, but relevant laws and regulations are inadequate, and the risk of data leakage and abuse is high. In addition, when public health emergencies occur, the emergency response mechanism of the monitoring system lacks a clear legal basis, resulting in unclear responsibilities among various departments during collaborative operations and affecting the efficiency of epidemic prevention and control.

4. Optimization path of the infectious disease monitoring system in public health emergencies

4.1. Establish a multi-channel, multi-level monitoring network

Building a widely covered, multi-channel, and hierarchical monitoring network is the foundation for improving infectious disease monitoring capabilities. At the horizontal level, besides traditional medical institutions, sentinel points, monitoring should be extended to key places such as pharmacies, schools, nursing homes, and transportation hubs. For example, pharmacies should be required to register and report information on individuals purchasing specific drugs, such as fever reducers and antibiotics, capturing potential epidemic signals through changes in drug sales data. Health monitoring specialists should be established in schools and nursing homes to record daily health status and promptly detect clustered outbreaks [8]. At the vertical level, grassroots monitoring capabilities should be strengthened by equipping remote areas and primary medical institutions with advanced detection equipment, such as portable pathogen detectors, and achieving technical linkage with superior medical institutions through remote medical systems. Simultaneously, public participation channels for monitoring should be established, and epidemic reporting mini-programs should be developed to encourage the public to actively report abnormal health conditions, forming a multi-level monitoring network that combines professional monitoring with social participation.

4.2. Improving the monitoring index system and early warning mechanism

A scientific and reasonable monitoring index system and a sensitive early warning mechanism are key to the early prevention and control of infectious diseases. In terms of monitoring indicators, besides the traditional indicators such as the number of cases and deaths, environmental monitoring indicators (such as water bodies, air microbial content), animal epidemic indicators (such as the occurrence of diseases in poultry farms), and behavioral monitoring indicators (such as people’s medical seeking behavior, search keyword popularity) should be added. Through a comprehensive analysis of multi-dimensional indicators, we can more accurately judge the occurrence and development trend of

infectious diseases. In terms of early warning mechanisms, a tiered warning model should be adopted, which divides the epidemic severity and transmission risk into four levels: general, moderate, severe, and extremely severe, and formulates corresponding response measures. By introducing artificial intelligence and machine learning algorithms, real-time analysis of monitoring data can be conducted. When abnormal fluctuations occur in the data, the early warning system will be automatically triggered to ensure that epidemic information can be timely transmitted to relevant departments and the public.

4.3. Enhancing the collection, analysis, and utilization of monitoring data

Improving the quality of monitoring data and the level of analysis and utilization is the core of optimizing the monitoring system. In the data collection process, it is necessary to strengthen the training of medical staff, standardize the filling process of infectious disease report cards, use information technology to achieve automatic data collection and verification, and reduce human errors. At the same time, it is important to unify the data standards and interfaces of information systems in different regions and medical institutions to achieve seamless data integration. In terms of data analysis, a professional team of data analysts should be established to use big data analysis, epidemiological models, and other technologies to deeply explore the patterns and trends behind the data [9]. For example, by constructing infectious disease transmission models, the spread scope and speed of the epidemic can be predicted, providing a scientific basis for the allocation of prevention and control resources. In terms of data utilization, a data sharing platform should be established to provide timely feedback analysis results to medical institutions, disease control departments, and government decision-making departments, providing strong support for epidemic prevention and control, medical resource allocation, and policy formulation.

4.4. Strengthening the management and release of monitoring information

Standardizing the management of monitoring information and timely and accurate release is conducive to improving public trust and prevention and control efficiency. A strict information management system should be established, clarifying the responsible entities and operating norms for each link of information collection, storage, transmission, and use, to ensure information security and privacy protection. Encryption technology and access control should be adopted to prevent the leakage and abuse of monitoring data. In terms of information release, principles of timeliness, accuracy, and transparency should be followed, and authoritative information release channels such as government official websites and social media platforms should be established. Regular releases of epidemic updates, prevention and control measures, health tips, and other information should be made to timely respond to public concerns [10]. At the same time, it is necessary to strengthen the review and management of information release content to avoid the spread of false information and improve public trust and recognition of epidemic information.

4.5. Enhancing the legalization and standardization of the monitoring system

Sound laws, regulations, and standardized systems are the guarantee for the effective operation of the monitoring system. It is necessary to improve the relevant laws and regulations on infectious disease monitoring, clarify the responsibilities and obligations of various departments and units in monitoring work, specify the legal responsibilities for violations such as concealed reporting and omitted reporting, and strengthen law enforcement to ensure that monitoring work is carried out according to laws and regulations. Technical specifications and operational guidelines for infectious disease monitoring work should be formulated to unify and standardize monitoring indicators, data collection methods, reporting processes, etc., improving the standardization level of monitoring work. Propaganda and

training on laws, regulations, and technical specifications should be strengthened to enhance the legal awareness and professional ability of relevant personnel and create a good legal environment.

4.6. Enhancing the rapid response capability of the monitoring system to cope with emerging and re-emerging infectious diseases

Improving the response capability to emerging and re-emerging infectious diseases is an inevitable requirement for the monitoring system to adapt to the new situation. Scientific research investment should be increased to support the research and development of new detection technologies, diagnostic reagents, and vaccines, improving the detection and identification capabilities for unknown pathogens. Establish a research platform for emerging infectious diseases, strengthen multidisciplinary collaboration, and quickly carry out etiology, epidemiology, and other research to provide a scientific basis for epidemic prevention and control. Regularly evaluate and conduct drills on the monitoring system, formulate special emergency plans according to the characteristics of emerging and re-emerging infectious diseases, and carry out actual combat drills to test and improve the feasibility and effectiveness of emergency plans, thereby improving the emergency response speed and disposal capability of the monitoring system.

4.7. Promoting cross-departmental and cross-regional collaboration

Breaking departmental and regional barriers and strengthening collaboration is an important way to achieve efficient prevention and control. Establish a cross-departmental infectious disease monitoring coordination mechanism, led by the government and involving multiple departments such as health, transportation, customs, education, and technology. Hold regular joint meetings to jointly study and solve major problems in monitoring work, realize information sharing, and resource integration. In terms of cross-regional cooperation, establish a regional infectious disease monitoring collaboration network, strengthen the epidemic information notification and coordination of prevention and control measures between adjacent regions, and form a joint prevention and control mechanism. For example, establish cross-border infectious disease joint monitoring points in border areas to jointly respond to the risk of cross-border infectious disease transmission; establish unified monitoring standards and information platforms in urban agglomerations to achieve integrated management of epidemic prevention and control within the region.

5. Conclusion

The optimization of China’s infectious disease monitoring system is a systematic and continuous project. By sorting out the development process and drawing on international experience, we propose targeted paths such as building a multi-level monitoring network, improving data management mechanisms, strengthening legal guarantees, and cross-departmental collaboration. This can not only effectively compensate for the shortcomings of the existing system in terms of sensitivity, timeliness, and information sharing, but also provides a feasible solution for responding to emerging and sudden infectious diseases and building a solid public health safety defense line. However, the epidemic prevention and control situation is complex and changeable, and the optimization of the monitoring system needs to be continuously iterated with technological progress and social development.

Disclosure statement

The author declares no conflict of interest.

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