Research on the Sharing Mechanism of Health Code Information Resources in Public Health Emergencies: Postprint

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Abstract

[Purpose/Significance] This study investigates the formation mechanism of difficulties in health code information sharing during public health emergencies, proposes countermeasures and suggestions to improve health code information resource sharing, assists in precise epidemic prevention and control, and perfects the construction of information resource sharing mechanisms. [Method/Process] Using grounded theory research method and taking the health code in the COVID-19 pandemic as a typical case, this paper analyzes health code-related policy documents, media reports, and public comments to construct a formation mechanism and countermeasure model for the difficulty in health code information sharing. [Results/Conclusions] Under the influence of public health emergency characteristics and health code product driving factors, differences exist in the collection methods and content during the health code information collection stage, the code generation process, update and error correction during the information processing stage, the terminal display and precise judgment during the information application stage, and the preservation and security management methods during the information storage stage. Their combined effect leads to the formation of the phenomenon of difficulty in health code information sharing. The current status of the sharing mechanism is analyzed from three perspectives: policy norms, technical platforms, and organizational management, and systematic countermeasures and suggestions are proposed to promote the construction of government digital resource sharing mechanisms.

Full Text

Preamble

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Abstract: [Purpose/Significance] This study explores the formation mechanism of difficulties in sharing health code information during public health emergencies, proposes countermeasures to improve health code information resource sharing, and aims to enhance precise epidemic prevention and control while refining the construction of information resource sharing mechanisms. [Method/Process] Using grounded theory methodology and taking the health code in the COVID-19 pandemic as a typical case, this paper analyzes relevant policy documents, media reports, and public comments to construct a model of the formation mechanism and countermeasures for health code information sharing difficulties. [Result/Conclusion] Under the influence of public health emergency characteristics and health code product drivers, differences exist in collection methods and content during the information acquisition stage, code generation processes and update/error-correction mechanisms during the information processing stage, terminal display and precise judgment during the information application stage, and preservation and security management methods during the information storage stage. These factors collectively contribute to the formation of health code information sharing difficulties. The study analyzes the current state of sharing mechanisms from three perspectives—policy norms, technical platforms, and organizational management—and proposes systematic countermeasures to promote the construction of government digital resource sharing mechanisms.

Keywords: public health emergencies; government digital resources; information sharing; health code; grounded theory

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The COVID-19 pandemic is the most significant public health emergency since the founding of the People' s Republic of China, characterized by the fastest transmission speed, widest infection scope, and greatest prevention and control challenges. Its features of harmfulness, infectivity, suddenness, and group occurrence require government departments to possess rapid response capabilities and implement high-quality decision-making after the event occurs. To meet the requirements of precise epidemic prevention and control and social order restoration, the health code—an innovative product integrating big data, artificial intelligence, and other emerging technologies—emerged.

According to statistics, health code applications have accumulated over 26 billion visits, more than 9 billion code presentations, and covered 1 billion people. However, under the requirements of normalized epidemic prevention and control, health codes have also revealed numerous problems. By December 2020, over

100 different health codes had been launched across various regions in China, such as Hangzhou' s "Health Code," Beijing' s "Health Kit," Shanghai' s "Suishen Code," Guangzhou' s "Suikang Code," Chengdu' s "Tianfu Health Code," Xi' an' s "Yimatong," and Chongqing' s "Yukang Code." In some areas, multiple health codes were used simultaneously, resulting in phenomena like "one person, multiple codes" and redundant data reporting. Regional health codes could not be mutually recognized, reducing the efficiency of work resumption and economic and social order restoration.

What are the reasons for the difficulty in mutual recognition of health codes? What is the formation mechanism of health code information sharing difficulties? What kind of information resource sharing mechanism should be constructed in public health emergencies? This study takes the health code product in the COVID-19 pandemic as an example, uses grounded theory analysis to explore the formation mechanism of information resource sharing difficulties in public health emergencies, and proposes countermeasures from policy norms, technical platforms, and organizational management perspectives.

2 Literature Review

The impact of major public health emergencies has intensified society' s demand for government information resource sharing, making it a key focus for scholars in information management, public administration, crisis management, and other fields. Research on government information resource sharing began in the 1980s, primarily focusing on how to use information technology to reshape government information resource sharing processes. Starting in the 1990s, scholars discovered that information resource sharing involves complex interactions among policies, management, participating organizations, and personnel, proposing that non-technical factors play a more important role in sharing mechanism elements. This shifted the focus from "technological determinism" to integrated elements of technology, management, and policy.

Scholars have explored specific mechanisms for government data sharing, such as dynamic mechanisms, incentive mechanisms, collaborative mechanisms, promotion mechanisms, interaction mechanisms, and government data information open sharing guarantee mechanisms. Some official documents and research reports also mention cross-departmental government data sharing mechanisms, such as China' s State Council' s "Interim Measures for the Management of Government Information Resource Sharing" (State Council Document [2016] No. 51).

Research on constructing government information resource sharing mechanisms can be broadly divided into two categories. First, studies on obstacles to government information resource sharing. For example, Chen Lanjie and Liu Yanlin pointed out that the traditional dual-matrix structure of government organizational frameworks leads to a lack of unified leadership, departmental fragmentation, information rent-seeking, absence of unified information operation

platforms, and lack of top-level design and guarantee mechanisms, which become major obstacles to government information resource sharing. Ma Haiqun and Jiang Shangqian argued that obstacles to government information resource sharing are mainly conceptual, institutional, and technical. Conceptual obstacles include government personnel clinging to departmental interests, resisting data openness and sharing, and emphasizing hardware over software and management over service. Institutional obstacles include independent departmental administrative organizations, poor information flow, broken information links, and poor communication. Technical obstacles include inconsistent data collection standards and specifications, non-uniform network platforms, and information security issues.

Second, studies on implementation paths for government information resource sharing. For instance, Song Yi et al. proposed a theoretical framework for cross-departmental collaborative mechanisms based on the three elements of "power-interest-information" through case analysis of government information resource sharing in the big data era. Zhu Xiaofeng et al. explored the symbiotic evolution mechanism of government data openness and sharing using the COVID-19 pandemic as an example, suggesting that promoting trust and cooperation among stakeholders, integrating resources, and establishing reasonable and effective benefit distribution mechanisms can optimize government data openness cooperation and improve resource utilization efficiency.

Existing literature has achieved rich results in government information resource sharing research, but there remains room for improvement. Most existing research on digital resource sharing focuses on daily information resource sharing, whereas crisis situations like major public health emergencies require not only timely and precise information sharing but also dynamic real-time sharing across regions and departments. Unlike daily information resource sharing, sharing mechanisms in public health emergencies also need to have comprehensive disease monitoring and evaluation functions. Current research is insufficient on information resource sharing mechanisms in such contexts and requires in-depth exploration.

Therefore, this study takes the health code—an example of government digital resource sharing products in the COVID-19 pandemic—uses grounded theory analysis, and based on analyses of public health emergency characteristics and health code drivers, explores how factors in health code information collection, processing, application, and storage stages affect sharing difficulties. The study proposes countermeasures to promote government digital resource sharing, providing theoretical and practical references for improving precise prevention and control efficiency and accelerating socioeconomic order restoration.

3 Research Design and Results Analysis

3.1 Text Collection

As one of the widely recognized research methods in social science, grounded theory is a bottom-up, inductive qualitative research method that reduces researchers' preconceived notions and more effectively restores the original appearance of events based on authentic information materials. Therefore, using grounded theory analysis for health codes—a newly emerged innovative product responding to COVID-19—helps more authentically and objectively analyze information resource sharing problems. Based on existing research, this study developed a grounded theory research process diagram (see Figure 1 [Figure 1: see original paper]), which includes three stages: theoretical preparation, theoretical construction, and theoretical refinement.

This study limited the text data search timeframe to January 2020 to December 2020, covering both pre- and post-national health code standard issuance periods, and involving both strict epidemic prevention and control and normalized management stages. Cross-searching with multiple keywords such as "health code," "epidemic prevention code," "health certificate," "scan code travel," and "data sharing" on the Chinese Government website and local government portals yielded policy documents, national standards, and sharing-related regulations. The same search method was applied to CNKI and its "China Important Newspapers Full-text Database," supplemented by authoritative reports from official media and academic articles. Data were primarily collected from government documents at all levels and publications such as *People' s Daily*, *Health News*, *Science and Technology Daily*, *E-Government*, and *Chinese Journal of Virology*.

To avoid potential bias in official texts, media reports and public comments on health code information sharing were collected from search engines like Baidu using the same keywords and timeframe, with stratified random sampling based on browsing volume rankings. A total of 363 official texts and 2,123 self-media comments related to health codes were collected.

After data collection, screening was conducted based on the following principles: First, delete texts containing keywords but unrelated to this study; second, delete texts without substantive content; third, delete forwarded or duplicate texts to ensure originality. After screening, 239 official texts and 619 self-media texts were obtained. The resulting data were randomly divided by category, with 70% used for grounded theory model construction and 30% for model testing.

3.2 Open Coding

Open coding is the process of breaking down collected materials, assigning concepts, and recombining them in new ways. This study' s open coding involved analyzing collected texts to obtain initial concepts, then screening and categorizing these concepts to achieve conceptual categorization. For data analysis convenience, all texts were sorted and numbered using the format: text source

number - text number. Policy documents, official media reports, academic journals, and self-media reports were numbered 1 to 4 as text sources. For example, 1-1 represents the first text from the policy document category.

To exclude the influence of personal viewpoints and "academic preconceptions," two trained professional coders conducted independent coding work, with Cohen' s Kappa value used for reliability testing, yielding a reliability coefficient of 0.85, indicating good reliability. After organization, 100 initial concepts and 40 preliminary categories were obtained from the text data, as shown in Table 1 .

3.3 Axial Coding

Axial coding involves further analyzing the categories obtained from open coding and identifying main categories that connect numerous categories. After analyzing the preliminary categories, 13 main categories were obtained, including sharing policy norms, and 6 relationship categories were summarized by exploring internal connections among main categories, as shown in Table 2 .

3.4 Selective Coding

In selective coding, main categories and their preliminary categories are integrated to refine the core category and summarize a "storyline" that encompasses all categories. The core category identified in this study is "formation mechanism and countermeasures of health code information sharing difficulties," consisting of three components: situational background, health code, and information sharing countermeasures. Health code information sharing involves cross-departmental government information resource sharing, which is not a simple technological determination process but rather a result of multi-stakeholder participation and interaction and the fusion of multiple factors.

Situational background refers to the context of the COVID-19 pandemic as a public health emergency, characterized by harmfulness, infectivity, suddenness, and group occurrence, which significantly differs from daily government information resource sharing contexts. Under the influence of precise prevention and control, work resumption, travel safety, and other driving factors, society' s demand for health code products and their information resource sharing becomes more urgent. Information resource sharing in this context involves not only more government departments but also enterprises, hospitals, various social organizations, and individuals, requiring real-time updates and traceable movement trajectories.

Therefore, in each stage of the health code information processing flow and among the stakeholders involved in each stage, factors affect the formation of health code information sharing difficulties. According to the information processing model of "input-processing-output," this study divides the health code production process into four stages. In each stage, factors are deeply analyzed from information content, technical requirements, and participating stakeholders, combined with relevant literature on information resource sharing obstacles,

to clarify key factors causing sharing difficulties. For health code information resource sharing countermeasures, based on government information resource sharing mechanism research results, implementation paths for health code information resource sharing are proposed from three important aspects: policy, technology, and organization.

Based on this, this study forms the following storyline: Public health emergency characteristics and health code driving factors constitute the situational background for health code products. Differences exist in collection methods and content during the information collection stage, code generation processes and update/error-correction standards during the information processing stage, which lead to poor data interoperability across regions. This subsequently affects terminal display and precise judgment during the information application stage. In the information storage stage, differences exist in information preservation and security management methods. The combined effect of all these stage factors leads to the formation of health code information sharing difficulties. Meanwhile, the current state of government digital resource sharing mechanisms is analyzed from three perspectives—policy norms, technical platforms, and organizational management—and optimization suggestions are proposed to address this problem. Thus, this study constructs the "formation mechanism and countermeasures of health code information sharing difficulties" model, as shown in Figure 2 [Figure 2: see original paper].

3.5 Theoretical Saturation Test

To test whether the model is complete, the data reserved for testing were recoded following the above procedures to complete the theoretical saturation test. The obtained categories and relationships all belonged to existing core categories, indicating that the "formation mechanism and countermeasures of health code information sharing difficulties" model has theoretically reached saturation.

4 Model Interpretation and Countermeasures

4.1 Situational Background Drives Health Code Information Sharing

As a typical major public health emergency, the COVID-19 pandemic possesses characteristics of harmfulness, infectivity, suddenness, and group occurrence. Population clustering and close contact lead to universal susceptibility across groups, causing serious health consequences and socioeconomic losses. The pandemic context and four types of driving factors make society's demand for health code products and their information resource sharing increasingly urgent.

"Precise prevention and control," as one of the important driving factors, refers to implementing graded and region-specific precise prevention and control down to the individual level through health code development when the domestic epidemic situation continues to improve. The driving factors of "work resumption" and "travel safety" use health codes to ensure safety in travel and workplaces during work resumption, promoting socioeconomic order restoration. Additionally,

achieving "community grid management" is also an important driving factor for health code information sharing, which helps implement responsibilities at the grassroots level of streets and communities and prompts communities to adopt thorough and effective measures to prevent epidemic spread.

Therefore, Yuhang District in Hangzhou took the lead nationwide in launching the "Yuhang Green Code" for travel control. The health code scheme of "one person, one code, scan to determine" received unanimous recognition, and most domestic regions also rapidly developed and promoted health codes in mid-to-late February 2020.

4.2 Formation Mechanism of Health Code Information Sharing Difficulties

To deeply study the problem of health code information sharing difficulties, this paper explores four stages based on the information processing framework: information collection, information processing, information application, and information storage.

In the information collection stage, differences in health code data "collection methods" constitute an important factor causing sharing difficulties. First, "collection subject" differences are reflected in the fact that different functional departments manage health codes across regions. For example, Guangdong and Jilin are managed by government service data management departments, while Heilongjiang is led by public security departments, resulting in independent information collection by various regions and departments without effective interoperability mechanisms at the initial stage. Second, "collection methods" differ, with centralized collection obtaining information through backend databases and individual reporting, while distributed collection obtains location information through installed applications using Bluetooth or ultrasound.

Regarding "collection content," significant differences existed across regions before national standard issuance, and even after national standard issuance, collection content still varies due to actual epidemic prevention and control needs.

In the information processing stage, local competent departments typically entrust third-party enterprises to complete the "code generation process." Due to different entrusted enterprises, the health code standards, algorithm technologies, and management levels initially set by enterprises vary, leading to differences in "health level classification" and "health level connotation" across regions. Influenced by the "code generation process," the "update and error-correction" mechanisms for health code information also differ across regions.

Regarding "update differences," health code information update times and rates vary, especially in regions recently downgraded from high or medium risk to low risk, where public travel may involve health code information misjudgment. Regarding "error-correction mechanisms," after the public appeals information errors, the two correction mechanisms of manual verification and data self-

checking also lead to health code update problems and data asynchronization.

In the information application stage, scene differences in "terminal display" lead to varying requirements for health code collection and classification, also causing health code information non-uniformity. In "precise judgment," government departments calculate based on health code big data to identify and adjust national risk region classifications in real time and locate high-risk personnel and their interpersonal contacts based on individual travel trajectory positioning. However, no consensus has been reached on how extensively deeper personal privacy information should be publicly shared and whether it involves security issues.

In the information storage stage, regional differences exist in "preservation subjects" for health code information, including uploading to national platforms, regional self-retention for self-use, and authorized enterprise preservation, leading to poor data accessibility. Differences in "backup management" and "call authorization" exist across regions, with a few regions authorizing lower-level departments to efficiently and conveniently call data, while most regions still require explicit instructions from higher-level departments.

In the main category of "information security," different data verification intensities across regions lead to mutual distrust and doubts about "data authenticity." Regarding "information security technology" and "information privacy protection," uneven technical levels across regions and departments also create sharing obstacles. Therefore, from collection, processing, and application to storage, factors in each stage collectively lead to the formation of health code information sharing difficulties.

4.3 Health Code Information Sharing Countermeasures

In response to the formation mechanism of health code information sharing difficulties, countermeasures can be proposed from three perspectives: policy norms, technical platforms, and organizational management.

From the policy norms perspective, existing research has proven that the completeness of policies and regulations has a significant positive effect on the sharing process. Therefore, in the context of public health emergencies, data sharing with urgent and special purposes, such as health codes, requires strengthened top-level design from the policy norms perspective to construct a digital resource sharing policy methodology system. "Sharing policy protocols" refer to policies, documents, and measures issued by the State Council and provincial and municipal governments to regulate data collection, processing, authorization, management, and privacy protection, providing guiding norms for solving information resource sharing problems, such as the "Interim Measures for the Management of Government Information Resource Sharing" (State Council Document [2016] No. 51), "Interim Measures for the Management of Government Information Resource Sharing in Jiangsu Province" (Jiangsu Government Document [2017] No. 133), and "Interim Measures for the Management of Electronic

Government Project Construction in Shenzhen" (Shenzhen Government Document [2006] No. 142).

"Sharing supervision" refers to the need for supervision mechanisms to ensure the implementation of sharing policies after their issuance. For example, during the COVID-19 pandemic, joint prevention and control institutions were established through national policies and regulations, with clear supervision subjects, supplemented by supervision, assessment, and reward-punishment measures to ensure the normal operation of the data sharing system. "Supporting resource support" refers to the need for relevant technical resources, technical personnel, and special funds to support the data sharing mechanism. For example, the current "government big data" projects promoted across regions require supporting resources to ensure implementation beyond issuing sharing policies and regulations.

From the technical platform perspective, establishing technical standards for data collection, processing, storage, and other stages has direct reference value for promoting digital resource sharing. For specific products, national or industry standards must be provided from the technical level to unify data collection standards and clarify code generation processes. For example, in April 2020, the Personal Health Information Code Data Format (GB/T 38962-2020) and Application Interface (GB/T 38963-2020) standards formulated by the State Administration for Market Regulation and the Standardization Administration of China technically specified data collection and calling, unified population, travel, health, and other information classifications, data formats, and data interface calls, initially solving sharing problems caused by differences in data collection content and methods.

Regarding "national platform docking," constructing a national-level technical platform for important digital resources in public health emergencies has important value for promoting data sharing and docking. Building a technical platform with national strength, authorizing regions to directly use the national platform, or using the national platform as an intermediary to open data reporting or extraction permissions helps accelerate information docking and sharing and promotes mutual trust and recognition of information across different application scenarios. Additionally, for "information security protection," since information in public health emergency contexts involves considerable personal privacy, technical specifications must be formulated for the sharing process, such as data encryption, backup, and authorization verification mechanisms during sharing, to ensure information security and solve current information security and privacy protection problems.

From the organizational management perspective, the construction of government digital resource sharing mechanisms in public health emergencies requires collaborative management by organizational institutions. First, "sharing risks must be clarified." Research shows that policy norms and organizational reality often differ, and the degree of inter-organizational sharing largely depends on considerations of risks and benefits. Therefore, unified data verification intensity

across regions is needed to reduce data risks, standardized information transmission and preservation across regions to reduce security risks, and clarified epidemic prevention responsibilities to reduce political risks.

Second, "sharing benefits should be coordinated." Timely and effective data sharing can assist other regions in quickly determining risk personnel trajectories, improve epidemic prevention response speed, and save social resources. For example, the small-scale outbreak at the Xinfadi Agricultural Products Wholesale Market in early June 2020 benefited from effective digital resource sharing among departments, enabling precise searching for high-risk personnel and rapid response in case-clustered areas, with all 335 confirmed cases cured within less than two months. Therefore, proper coordination of sharing benefits helps stimulate sharing behavior.

Finally, "sharing values should be cultivated." The erroneous concept of local governments acting independently and viewing departmental information as internal property needs to be changed, and sharing values should be promoted at both leadership and implementation levels.

5 Conclusions and Recommendations

Although the domestic epidemic situation has gradually stabilized, the international epidemic situation remains severe. To consolidate anti-epidemic achievements and promote comprehensive social order restoration, higher requirements for normalized and precise epidemic prevention and control are needed, making the deep application and mutual trust recognition of health codes more urgent. This study takes phenomena such as one person with multiple codes, redundant reporting, and difficulty in mutual recognition as entry points, uses grounded theory to construct the "formation mechanism and countermeasures of health code information sharing difficulties" model.

The research findings and theoretical contributions are as follows: First, this study reveals the formation mechanism of information sharing difficulties in public health emergencies. Existing literature has mostly analyzed government digital resource sharing problems from organizational, motivational, and management perspectives, with less exploration of the intermediate mechanisms of sharing difficulties combined with information processing flows. This study, based on in-depth analysis of public health emergency contexts and health code product driving factors, explores key nodes affecting sharing from the information processing flow perspective, clearly revealing the formation mechanism of information sharing difficulties.

In the information collection stage, differences in health code collection subjects, methods, information classification, and data formats across regions collectively cause information sharing difficulties. In the information processing stage, differences in code processing standards, health code level classification, and level connotation lead to non-uniform update and error-correction issues. In the information application stage, application scenarios across regions, including spe-

cial scenarios, lack mutual recognition mechanisms. In the information storage stage, regional differences in information preservation subjects, backup management, and call authorization mechanisms are not unified, and uneven security guarantee technical levels lead to difficulty in mutual data trust.

Second, this study proposes sharing strategies for health code information resources in public health emergencies. Addressing health code information sharing difficulties, this study systematically summarizes the current state of information resource sharing mechanisms from three perspectives—policy norms, technical platforms, and organizational management—and proposes targeted solutions from macro, meso, and micro levels and from policy, technology, and management dimensions.

From the policy norms perspective, top-level design for sharing policies should be improved, emphasizing systematic and executable institutional norms, clarifying main responsibilities in supervision, and constructing a regulatory system to provide necessary hardware resources for functional departments. From the technical platform perspective, data collection standards should be further unified, and local governments should be moderately authorized to report or extract data on the national health information platform to meet the requirements of normalized epidemic prevention and control for timely tracking of mobile populations, especially high-risk personnel, ensuring information security and privacy protection throughout platform construction.

From the organizational management perspective, the relationship between departmental sharing risks and benefits should be further coordinated from three risk types: data, security, and political. While obtaining positive impacts and benefits from digital resource sharing, risk responsibilities should be clarified, sharing values should be cultivated, and cooperative trust relationships between regions and departments should be deepened.

Regarding research limitations and future directions, this study uses grounded theory, a standardized qualitative research method, to construct the model. Future research could explore intermediate mechanisms from other perspectives, such as stakeholder perspectives, and could combine quantitative data-based empirical research to further clarify the influence intensity among categories and variables.

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Author Contributions

Li Huaqiang: Designed the research framework, interpreted the model, and wrote the paper.

Zhao Yu: Conducted text data analysis and wrote and revised the paper.

Note: Figure translations are in progress. See original paper for figures.