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Process Reengineering: China's Public Health Emergency Information System

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ABSTRACT

The SARS crisis has exposed the inability of China's fragile public health system to respond to emergencies. China's central government has initiated a national project to establish a public health emergency information system (PHEIS). The purpose of this study is to investigate the ongoing development of China's PHEIS. By using a functional coupling framework, the paper analyzes the weakness of the old public health system, describes the design and functionalities of PHEIS, and discusses implications on future system development from a process reengineering perspective.

KEYWORDS

Public health, surveillance, emergency information system

Introduction

The outbreak of SARS (severe acute respiratory syndrome) in China in early 2003 has drawn much attention to China's public health information system. Qiang Gao, the new leader of the Ministry of Health (MOH), admitted:

In terms of our work, the MOH was not well prepared against the sudden public health hazards and its epidemic prevention system was relatively weak. Following the outbreak, the Ministry failed to institute a timely and unified mechanism for collecting, processing and reporting the relevant information nationwide and it did not give out clear-cut instructions or effective guidance. ... Due to a lack of a sound system of information collection, surveillance reporting and contact tracing there have appeared major weaknesses in statistics compilation on the epidemic on the part of the relevant agencies and accurate figures have not been reported to higher authorities in a timely manner.

After the outbreak of SARS, the Chinese government realized the flaws inherent in its former public health systems and started making tremendous efforts to improve the processes of public health operations. One of China's major efforts was to allocate billions of dollars to build a public health emergency information system (PHEIS). The purpose of this paper is to investigate the ongoing development of China's PHEIS. Drawing on the business process reengineering (BPR) theory, the paper analyzes the weakness of the former public health system, describes the design and functionalities of PHEIS, and provides suggestions on how to improve PHEIS. The research questions that this paper attempts to answer are:

1. Why would the current public health information system not work in terms of emergency response?
2. What are the critical factors that make PHEIS a success?
3. What was learned for future development of public health emergency information systems?

LITERATURE REVIEW

Past and potential biological attacks have resulted in an enormous crisis for the worldwide public health. Crisis management involves a complex set of tasks that call for the utilization of diverse information technologies to respond to emergencies. Much research has been conducted to study the improvement of public health systems by using IT so that public health emergencies can be handled in a competent manner. Popovich et al. proposed a framework for an integrated disease surveillance system for rapid detection, tracking, and managing of public health threats. The framework contains six different functions, which are collection, detection, alert and early warning, resource planning, response assessment and evaluation, and investigation and modeling (Popovich, Henderson and Stinn, 2002). Kun and Bray (2002) contend that state and local health departments should build dual- or multiple-use public health information infrastructure tools. Dual-use means that the public health information system should be able to respond and detect not only bioterrorism, but also other infectious disease

outbreaks, chemical spills or leakages, food and water contamination scenarios, and animal disease outbreaks (Kun and Bray, 2002). Turoff and his colleagues introduced the development of Office of Emergency Preparedness (OEP), which was a civilian agency that could exert command and control over all federal resources upon the declaration of a federal emergency. They presented a workflow communication process which involved reporting between various roles in the emergency and resource acquisition and allocation (Turoff, 2002, Turoff, Chumer, Walle and Yao, 2003). Although the workflow communication process proposed by Turoff et al. is intended for general emergency responses, it has implications in the context of public health.

The extant literature has provided an exploration about how to respond to public health emergencies by leveraging the power of IT. However, the majority of prior studies are based on experiences in the US. Given that a public health emergency could easily spread across countries and pose a global threat (e.g., the SARS outbreak), the scope of research on public health emergency response should be extended to include developing countries which are more vulnerable to bioterrorist attacks and are more likely to nurture epidemic diseases. China is the country where SARS has caused the most serious damage; hence its initiatives of developing public health emergency response systems are interesting enough to make a case.

THEORETICAL FRAMEWORK

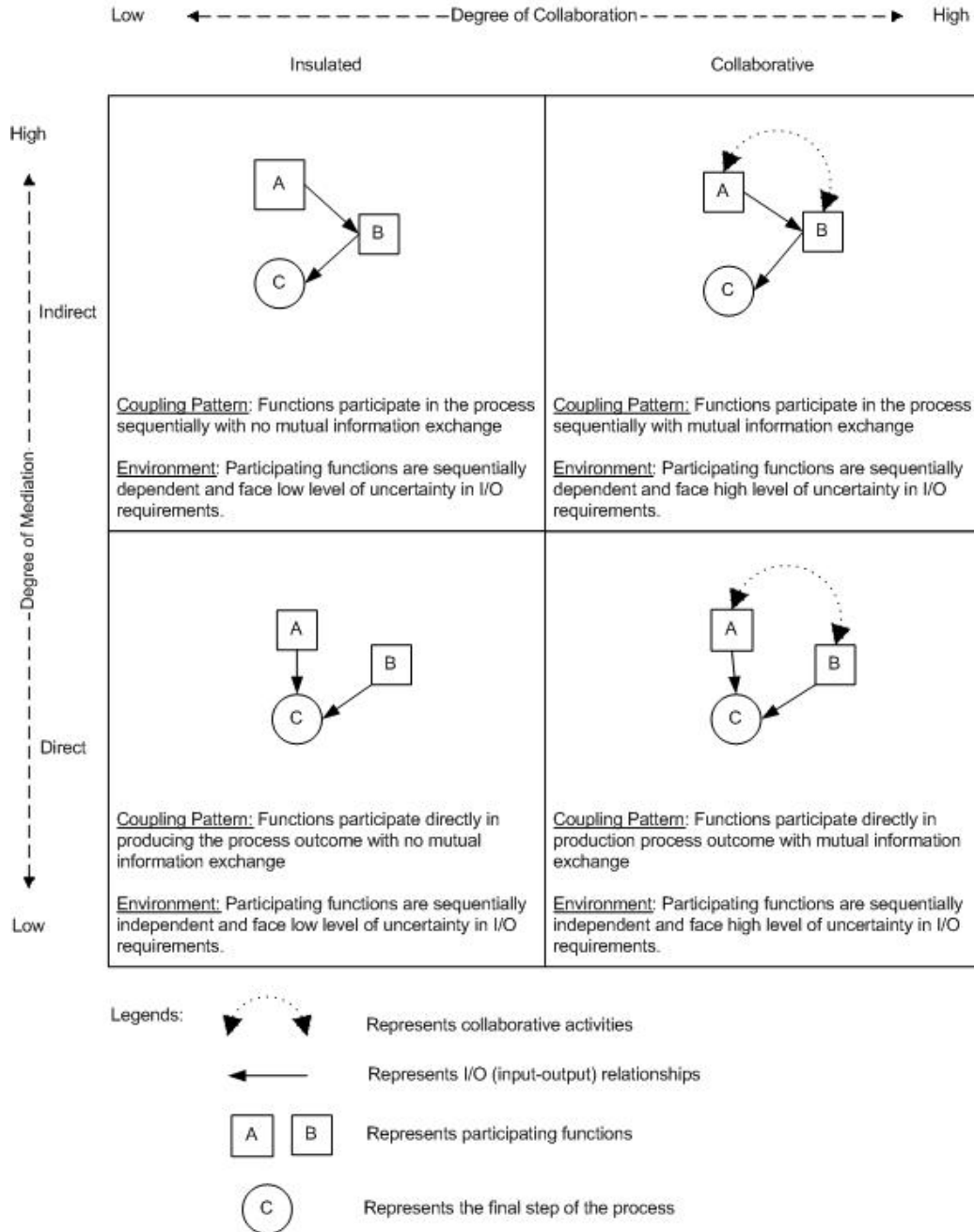
Since emergency response information system is a relatively new research area, there are few theoretical developments. In this paper, we employed a Functional Coupling Framework of Business Processes developed by Teng, Grover, and Fiedler (1994). We argue that this framework is applicable because of the similarity between characteristics of business processes and emergency response processes. A business process refers to a set of logically related tasks performed to achieve a defined business outcome (Davenport and Short, 1990), while an emergency response process could be defined as a set of related tasks performed to cope with an emergency. Both processes face a challenge of integrating different tasks so that they are orchestrated to achieve a common goal. Therefore, the framework developed for business processes could be modified to fit in the context of emergency response processes.

A process can be redesigned to achieve maximum performance gains (Hammer, 1990). Business Process Reengineering (BPR) refers to "the critical analysis and radical redesign of existing business processes to achieve breakthrough improvements in performance measures" (Teng, Grover and Fiedler, 1994). A business process encompasses a set of participating functions and tasks, and BPR is usually enabled by IT applications which modify how these participants are coupled to each other to attain dramatic performance improvements. The functional coupling framework depicts the coupling patterns among different participants of business processes (Teng et al., 1994). Two critical dimensions are conceptualized in the framework to capture the characteristics of a business process: *degree of mediation and degree of collaboration*. A process with a high degree of mediation involves a large number of steps in a sequential manner, while processes with a low degree of mediation have most of the participants contribute directly, often simultaneously, to the final outcome. For the degree of collaboration dimension, the participants in a process, regardless of the pattern of mediation, may exchange information with each other and make mutual adjustments to facilitate the accomplishment of process outcome. Depending on the extent of such information exchange, one can identify processes having higher or lower degree of collaboration. This gives rise to a framework that delineates four general process patterns: high-mediation/low-collaboration, high-mediation/high-collaboration, low-mediation/low-collaboration and low-mediation/high-collaboration as shown in Figure 1.

While all of the four patterns are possible in the context of emergency response systems, the low-mediation/high-collaboration pattern is most likely to generate the best performance. On the one hand, emergencies should be handled in a time urgent manner. A high degree of mediation tends to delay the responding time should an emergency occurs, since the critical information has to go through each intermediate participants before it ultimately reaches decision makers. On the other hand, emergency response is such a complex process that affects and is affected by a variety of participants. Prior research suggests that an emergency system needs to define roles, develop collective understandings, and maintain effective coordination (Bigley and Roberts, 2001, Turoff et al., 2003). It is hardly to be successful without effective collaboration between different participants due to the great uncertainty in the event of an emergency. As a consequence, various measures need to be employed to decrease the degree of mediation and increase the degree of collaboration for emergency response systems.

The functional coupling framework postulates that the degree of mediation can be reduced by application of shared information resources such as central databases and imaging technologies and the degree of collaboration can be enhanced by application of communication technologies such as telecommunications networks, emails, and groupware. In essence, both shared information resources and communication technologies are utilized to support efficient and effective communications among various participants of a certain process. The former shortens the communication distance and the latter broadens the

communications scope. Both are indispensable in public health emergency response systems. According to Edward Baker, assistant US Surgeon General, "... the major public health challenges since 9/11 were not just clinical, epidemiological, technical, issues. The major challenges were communication. In fact, as we move into the 21st century, communication may well become the central science of public health practice."



Adapted from Teng, Grover, and Fiedler (1994) *Business Process Reengineering: Charting a Strategic Path for the Information Age* *California Management Review* 36(3)

Figure 1. A functional coupling framework

METHODOLOGY

Given the complexity of China's public health processes and the lack of literature on this topic, a case research method was adopted for this study. Interviews with two MOH officials, an IT specialist in China's CDC, two professors at Health Science

Center of Beijing University, three healthcare informatics experts, and six healthcare IT practitioners were conducted to collect data about the former public health processes and the development of China's PHEIS. Additionally, government documents were reviewed to retrieve pertinent information. The case analysis is primarily based on the functional coupling framework described in the preceding section. The rest of this paper presents the case analysis.

PROBLEMS OF THE FORMER PUBLIC HEALTH INFORMATION SYSTEM

China's former public health information system (PHIS) has a hierarchical structure consisting of four major layers: county layer, city layer, province layer and central government layer (Figure 2). The primary objectives of the system are disease surveillance and monitoring. Major public health data collected by the system include epidemic report, disease surveillance, causes of death statistics, food hygiene, environment hygiene, school hygiene, women and children hygiene, profession hygiene, and public health resource allocation. The outbreak and spread of SARS has uncovered the deficiencies inherent in the PHIS, which are summarized as follows:

1. The disease reporting and surveillance cannot be carried out in a timely manner. Due to the hierarchical structure of China's PHIS, disease surveillance data are reported by following a bottom-up path and the reporting is performed on a 10-day or monthly basis. Despite the establishment of a virtual private network in 2000 for electronically transmitting disease surveillance data among the four layers of the PHIS, communication between the PHIS and the sites where public health raw data are collected is realized by snail mail or telephone. In addition, surveillance reports have to be approved by relevant officials at each layer before they can move up to the next layer. As a result, the reporting cycle time is prolonged and local officials' interference could affect the accuracy of the reports. During the SARS event, it took eight to nine days on average to report a SARS case from the patient's location to MOH, and three to four days to report a diagnosed SARS case from hospitals to MOH. The delayed reporting has largely contributed to the rampancy of SARS in China.
2. The coverage of the PHIS is relatively small. The network of the PHIS comprises a variety of centers of disease control and prevention (CDCs) which are at the county level and levels above. Although these organizations are able to shape a national net on which public health information can be exchanged in real time, the mesh size of this net is too big to catch timely disease information. Health care organizations at the grassroots level are usually the sites where public health emergency occurs; however, these organizations are not part of the PHIS network. As shown in Figure 2, epidemic disease information generated at the town and village level and hospitals is reported manually by filling out a reporting card and mailing it to the CDC.
3. The information flows in care-providing organizations are inefficient. When a public health emergency occurs, it is critical to gather accurate information regarding exploitable medical resources such as hospital beds available, transportation capability, physicians available, care giving capability, medical devices and equipments, medications and preventive equipments, so that the emergency situation can be managed to the maximum. Due to the inefficient inter-organizational information sharing in China's hospitals as well as the inefficient communication between hospitals and disease control organizations, the admission and transfer of SARS patients during the SARS event became chaos.
4. The public health regulatory system is insufficient. In China, only a few regions have established regulations to mandate and monitor the development and use of public health information systems. There is no unified regulations at the national level to ensure the exploitation of IS in disease surveillance and public health.
5. There is no standardized national platform for public health information exchange. China did not invest on the development of health information standards, coding schemes, and communication protocols. Although information systems have been widely used at health care providers, disease control and prevention organizations, and health management authorities, health information is confined inside boundaries of these entities and effective health information sharing could not be easily realized due to the nonexistence of a standardized platform.

Using the functional coupling framework, we can easily notice that the various players participate in the disease reporting process indirectly, with many intermediate steps, and a sequential flow of electronic and paper documents. This leads to a high degree of mediation which negatively affects timely communications, thus causing delay of appropriate response to emergencies. In addition, the lack of inter-organizational information sharing signifies a low degree of collaboration which makes it difficult to allocate resources and coordinate group activities.

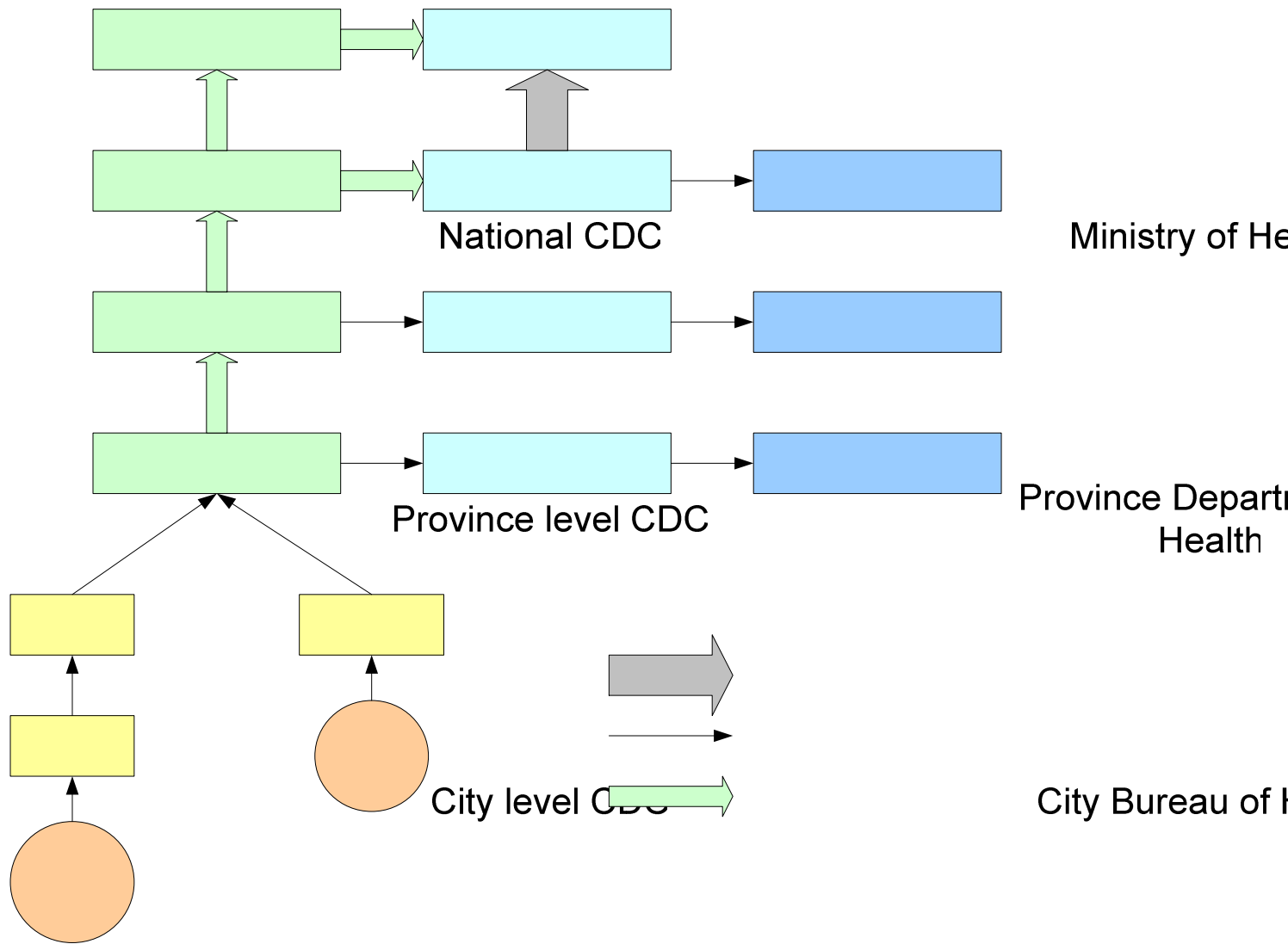


Figure 2. China's former public health reporting systems

DESCRIPTION OF PHEIS

The development of PHEIS involves extensive efforts in constructing four components: (1) a surveillance system, (2) a command center, (3) an action system, and (4) a supporting system. Figure 3 illustrates relationships among these components and their functional characteristics.

Town

Hospital

Village

Epidemic

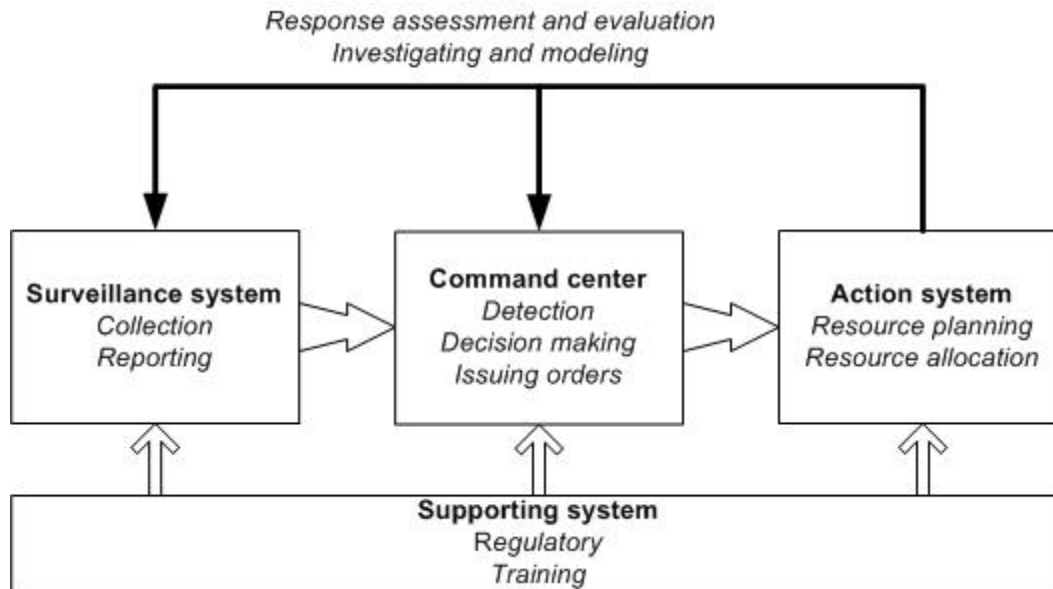


Figure 3. China's Public Health Emergency Information System (PHEIS)

Surveillance system

The objective of the surveillance system is to replace the periodical, hierarchical reporting with online reporting to meet the requirements of emergency alert and response. The reporting process will be greatly streamlined by implementing a central database. Authorized reporting individuals and organizations can perform online reporting, and health administrative agencies and CDCs are able to download reports of local epidemic events and public emergencies, both in real time (Figure 4). By using the central database, critical information can be shared among stakeholders quickly, easily, and accurately. All the participants of the emergency reporting process contribute to the process outcome directly and the intermediate steps are largely eliminated. As a consequence, the new system greatly reduced the degree of mediation in the emergency reporting process. In addition, training personnel who report public health emergencies at various health care organizations is also part of the surveillance system development.

Command center

The command center integrates public health, disease surveillance, medical care, and health regulation information by using the Internet platform. It intends to utilize the advanced information technology and management tactics to deal with public health emergencies. The system will monitor the entire emergency process and has such functionalities as data collection, crisis determination, decision support, command, deployment, real time communication, and onsite support. The purpose is to make the most appropriate response to the emergency in the shortest time so that available resources can be effectively and efficiently allocated and exploited. The systems in the command center encompass three application platforms and seven subsystems. The three application platforms are information platform, professional service platform, and decision-making platform. The seven subsystems include database system, geographic information system, remote monitor system, analysis and prediction system, virtual reality system, decision support system, and search and query system.

Action system

The action system is an important component of PHEIS. Under normal circumstances, this system is utilized to manage public health, provide medical services, facilitate emergency room services, and conduct telemedicine and other health activities. It is closely linked with healthcare, emergency rescuing, and CDC institutions. Once a public health emergency occurs, the action system will report relevant information to the command center and execute orders from the command center to allocate resources such as hospital beds, medications, medical rescuing equipments, telemedicine services, long distance training and other healthcare services. The action system will connect information systems implemented in organizations which participate in the emergency response process. The electronic linkage among these organizations will largely enhance the degree of collaboration of the emergency response process and facilitate the achievement of optimum emergency response outcomes.

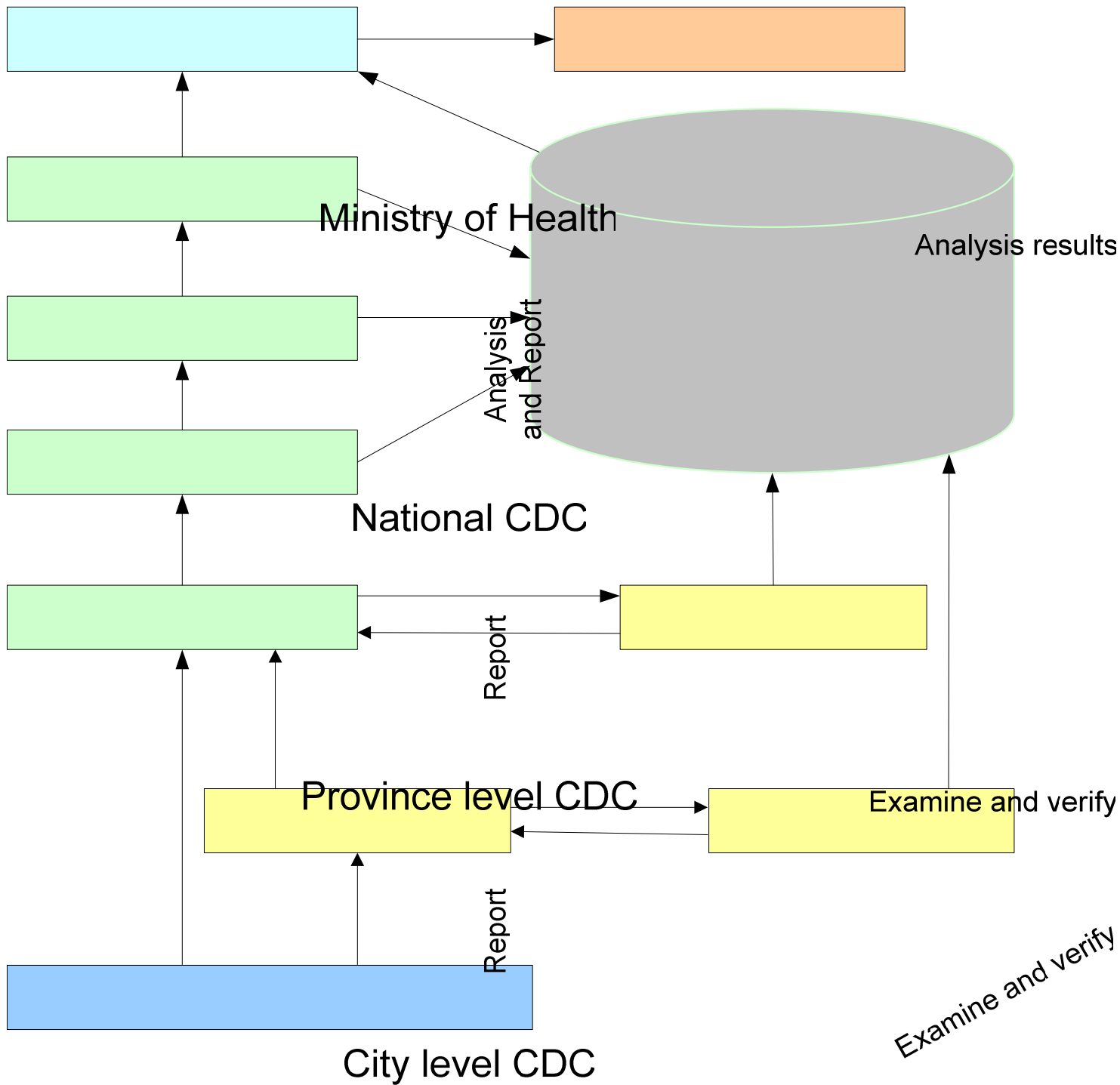


Figure 4. China's current public health reporting system

Supporting system

The supporting system is primarily a public health regulatory information system. The purpose of this system is to monitor the behavior of health care administration bodies and health care organizations in fulfilling their legal obligation of protecting public health. The supporting system requires the establishment of public health regulatory LAN and central databases at the provincial and national levels. All the public health supervising agencies need to connect to the two LANs through the

County level CDC

Insert

Trace and M

national public data network. Standardized format of regulatory reports will be developed. Online reporting and digital data collection methods will be explored.

By leveraging the advanced information technology, the development and implementation of China's PHEIS will reduce the degree of mediation and enhance the degree of collaboration of the emergency response process. The major improvement over the former system is the reduction of the degree of mediation. Traditionally, China exercises a strict central-control system and every task should get approval from a superior agency before it is started. The local CDCs and other organizations participated in the disease reporting process indirectly, with many intermediate steps, and a sequential flow of paper and electronic documents. After reengineering, the high degree of mediation is changed with the help of a shared database. Now, reporting activities are no longer triggered by the flow of documents. Instead, every CDC, hospital, clinic, or other healthcare organization participates in the process directly, with information from the shared database and without mediation from other participants. This process embedded in PHEIS indicates a radical change which could lead to dramatic improvement of emergency response outcomes. The enhancement of the degree of collaboration is also very important; however, its importance is overshadowed by the importance of the mediation problem given that China's SARS spread was mainly caused by its inefficient reporting system.

DISCUSSION

Critical success factors of PHEIS

The successful development of PHEIS depends on several critical success factors. First, the development of PHEIS is initiated by China's central government. The MOH issued detailed plans to direct the development and passed regulations to force the implementation. The emphasis of the central government largely legitimizes the efforts of local governments and healthcare organizations in developing PHEIS. Second, China learned a lesson the SARS outbreak which caused serious damages. China has a firm commitment to reengineer its public health system so that future public health emergencies are managed competently. Finally, the planned funds are quickly appropriated.

Obstacles for PHEIS

The development of PHEIS is an undergoing process. There are a number of obstacles that need to be taken into account during the development process. Anticipation of possible obstacles will not only help the development of PHEIS, but give directions of future system development. The obstacles are described as follows.

First, the economic development in China is unbalanced. While developed provinces have the financial and technical capability to implement PHEIS, underdeveloped provinces might not be able to do the same because of the lack of IT infrastructure and other resources. Second, health information standards such as HL7 and DICOM are not available in China's public health information systems. Experience in the US has suggested the important role of using the HL7 standard for public health surveillance (Tsui, Espino, Dato, Gesteland, Hutman and Wagner, 2003). With a wide range of data sources in PHEIS, technical standards should be developed to avoid confusion and facilitate information sharing. Third, the relationship between PHEIS and local health information systems is unclear. Some parts of China have established regional or community health information systems and some hospitals implemented hospital information systems. How to integrate these information systems poses a challenge. Fourth, China's healthcare system does not require a unique patient identification number. In the process of disease surveillance, it is possible that the same patient is reported for many times, thus undermining the accuracy of surveillance data. Finally, the information system management ability in China's healthcare organizations is at a relatively low level and there are huge discrepancies between regions and organizations. As a consequence, health information integration at the national level is very difficult. In addition, incorporating clinical data into the public health surveillance system is not likely to realize in the near future.

Implications for Future Development

The development of PHEIS yields some implications for the future development of similar systems. One implication is that the functional coupling framework can be used to analyze the current process to identify which dimension can be possibly improved by reengineering. In China's situation, both the degree of mediation and the degree of collaboration need to be modified. For other countries, it is possible that only one dimension needs to be modified. The functional coupling framework provides an environment that facilitates determining the strategic path of transforming the current public health emergency response processes.

The mediation and collaboration problems can be solved by leveraging advanced information technologies. Yet simply applying information technologies might not be a total solution. As China's experiences suggest, without suitable health information standards, the power of advanced information technology cannot be brought into full play. Emergency response

is all about timely information transfer and accurate information interpretation. If two systems are not using the same standard, the information sent from one system will be useless to another regardless how advanced the systems are. Standardization has long been a challenge for healthcare researchers and practitioners. Western countries have made substantial progress in this area. In order to learn from western health information standards, China is translating HL7 and DICOM specifications. The functionality of China's PHEIS is limited by the lack of standards. While PHEIS has to tolerate this limitation due to the urgent need of a public health emergency system in place, future development should emphasize the critical role of standards.

Another implication for future system development is that the interface should be user-friendly and easy to use. A plethora of research has demonstrated one's perceived ease of use is a significant determinant of one's perceived usefulness and intention to use an information system (Adams, Nelson and Todd, 1992, Davis, 1989, Hu, Chau, Sheng and Tam, 1999). Considering the low IT using ability in China's healthcare organizations, the interface of PHEIS is designed as easy as possible. Figure 5 and Figure 6 show two snapshots of the online reporting system of PHEIS. For other developing countries, this rule should also be followed since ease of use can directly affect the success of a system implementation.

CONCLUSION

This article describes issues relating to the development of China's public health emergency information (PHEIS) system. By using the functional coupling framework, some insights are provided regarding the problems of China's former public health information system and the improvements that have been made in the PHEIS development. In addition, this article discusses critical success factors and obstacles of the development of PHEIS as well as implications for future system development. It is expected to be beneficial to IS researchers and practitioners, especially those who are interested in developing countries' public health emergency information systems.



Figure 5. National Diseases Reporting Information System Login Page

中华人民共和国传染病报告卡

报告卡编号

门诊号

病历(案)号

患者姓名

患儿家长姓名

*性别 男 女

年龄单位 岁 天 月

年龄

户籍 本省其他市(地) 本市其它县(区) 本县(区) 港澳台 其他省 外籍

外地来本地就医者 否 是

*发病地点

户口地址

现住地址

患者单位

联系电话

Figure 6. National Diseases Reporting Information System Reporting Form

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