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Analysis of Infectious Diseases Spreading Process and Ict-Based Management System

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ABSTRACT

Recently, as an interest in strongly contagious infectious diseases such as MERS increases, proper infectious disease management systems using ICT have been discussed. Particularly in Korea, the process-centered measures on the basis of ICT infrastructure and the internet of things are under discussion. However, studies on these are very rare. This study aims to propose an infectious disease management system in which ICT is incorporated into each process of the spread of infectious diseases. The scope of analysis is limited to the infectious diseases that flow from a country into the other country through air transportation. The process encompassing from the entry to the eradication of an infectious disease is classified into 5 stages (airport, transportation of patients, medical institutions, self-isolation, and waste disposal), and a journey map is suggested. Subsequently, an efficient infectious disease management system in which ICT is introduced to each stage is proposed. This study has significance in that it has unprecedentedly analyzed the entire spreading process of infectious disease from the process-centered perspective, and is expected to suggest a new convergence direction of ICT.

Keywords: ICT, IoT, Infectious disease management system, Health care system, Convergence, Journey map.

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Contribution/ Originality

This study contributes to construct the effective infectious disease management system and provide a new direction for the convergence of ICT in future.

1. INTRODUCTION

Recently, as infectious diseases such as MERS and ZIKA virus prevail, the worldwide interest in the measures to prevent and manage infectious diseases is rising. It is considered that the risk of country-to-country transfer of an infectious disease has been increased due to the lowered barriers between countries with the arrival of the global era and the ever-growing high population density. Under these circumstances, the necessity of systematic infectious disease response systems is suggested, and major countries in the world are making efforts to establish such systems. Particularly, Korean government and medical institutions have been promoting the establishment of an infectious disease management system based on advanced ICT infrastructure and the internet of things that is expected to be a future growth engine since experiencing high casualties due to 'MERS outbreak' in 2015.

Previous studies have been concentrated on the medical and policy aspects of infectious diseases, and infection within hospitals, and those focused on the entire process of the spread of infectious diseases are very rare. Hence,

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this study aims to propose an efficient infectious disease management system that incorporates ICT onto each stage of the spreading process of an infectious disease through the case study on infectious disease management systems in Korea.

In this study, the scope of infectious diseases is limited to the ones that flow from a country into the other country, and subsequently a journey map is suggested by classifying the life cycle of an infectious disease from the entry to the eradication into 5 stages. Furthermore, the limitations at each stage of the current infectious disease management system are discussed and which ICT will be efficient for being incorporated into each stage is analyzed from the process-centered perspective.

The composition of this study is as follows. In Chapter 2, theoretical studies and current status of infectious disease management systems are analyzed, and in Chapter 3, the research methods are explained and the process model is suggested. In Chapter 4, the ways to incorporate ICT into each stage of the process are suggested, and Chapter 5 finishes this article with conclusion and implications.

2. THEORETICAL BACKGROUND

2.1. Definition and Necessity of Infectious Disease Management Systems

In general, infectious diseases are disorders caused by various pathogens including virus, bacteria and parasites through infection. The infection by pathogens occurs through various paths such as food ingestion, inhalation of pathogens by respiration, and contact with other people. The infectious disease management system in this study is defined as a systematic management system that can minimize the spread of an infectious disease when it enters a country.

World Health Organization (WHO) pointed out that the main cause of MERS outbreak in Korea was the inadequacy of the management system at the spreading stage of the infectious disease rather than the contagiosity of MERS. Currently, as for the infectious disease management system in Korea, several issues have been raised for improvement, including the determination of accurate travel route of entrants, early identification and management of persons in close contact, compliance of hospitals to infectious disease management principles, thorough control of self-isolation, and complementation of regulations. It can be seen that the determination and management of the situations by sharing prompt and accurate information are needed in the spreading process of infectious diseases. Also, cultural issues such as visiting patients and the customary practice that a patient receives treatment from multiple medical institutions (medical shopping) have been raised. With such MERS outbreak as an opportunity, it was argued that the establishment of infrastructure for the strengthening of public healthcare and control of ecological crisis was fundamentally needed (Hee-Sun, 2015).

A new responsive measure to infectious diseases that improves and complements the existing infectious disease management system is needed. However, previous studies have been concentrated on policy and infections within hospitals.

Lee (2014) indicated not only the viral and epidemiological nature but also the limitations of the national healthcare system for the management of infectious diseases as the cause of the MERS outbreak in Korea. He argued that the healthcare resources, their organization, healthcare management, provision of healthcare service and the measures to policy problems of financial support in relation to the management of infectious diseases were urgently needed (Lee, 2014).

Park and Lee (2015) pointed out the issues of quarantine and isolation, the nonfeasance of administrative authorities, national compensation, and immunity of public officials given that most of infected patients were visitors to medical institutions and patients in the emergency room or ward. Therefore, they suggested that legal improvements would be necessary, including protection of rights according to international rules, delegation of

authority to administrative jurisdiction and application of public law principles to national compensation (Park and Lee, 2015).

Heo (2015) pointed out that the infection within hospitals by which a few initial confirmed patients transmitted the disease to dozens of patients could be attributed to ventilation conditions within the hospital, and mentioned the importance of the management of the hospital indoor air quality (Heo, 2015).

2.2. The Current Status of Infectious Disease Management Systems in Korea

Table-1. Analysis of the status of the current infectious disease management system in Korea

Stages	Analysis of the Status of the Infectious Disease Management System	Limitations
Airport	Using thermal camera and tympanic thermometer	Low accuracy, contact measurement
Transportation	Transported by an ambulance	Difficulty with identifying situations promptly
Medical Institution	Free movement within hospital	Risk of secondary infection from encountering many people
Self Isolation	Measurement and report of status during self-isolation	Difficulty with systematic management
Waste Disposal	Waste disposal	Risk of infection due to carelessness

Source: Author's data

Currently at airports in Korea, primarily the thermal camera and secondarily the tympanic thermometer are in use to measure the fever that is the initial symptom of the majority of infectious disease. The thermal camera is used in many countries despite the low accuracy because of its convenience. The US FDA does not accept the thermal camera as a dedicated device for mass screening of fever, and limits its use to an auxiliary measurement to the clinical diagnosis. In addition, secondary quarantine is carried out for the suspected patients found in the primary screening using the tympanic thermometer, which has a high risk since this contacts the human body. Therefore, a non-contact temperature monitoring system with high accuracy is needed.

Once diagnosed as the suspected cases, the patients are transported to the medical institution using an ambulance. The contact should be avoided as much as possible in order to prevent secondary infection when the suspected patients are transported. The system to be able to identify immediately available ambulances and the status information of medical institutions is required under these circumstances.

As pointed out in the MERS outbreak, a problem in the medical institution is that it is possible to have free access to other wards. Since medical staff, patients, and visitors have free access to other hospital rooms except for specific off limits areas, the system to control such 'contact' is required.

According to the response guidelines of the MERS outbreak, suspected patients without symptoms should take self-isolation until the test results come out. Temperature and respiratory symptoms are recorded for 14 days and the results are reported by wires. It is difficult to manage the self-isolated patients systematically in this process. Therefore, there is a need for a system that can identify the changes in body temperature while guaranteeing the day-to-day life of the self-isolated patients and take quick actions when abnormality is found.

Finally, the process to dispose the waste that can be generated at any stage of the spread of infectious diseases is also important. There is a risk of secondary infection such as being exposed to pollutants due to minor carelessness in the process of disposing the waste. Therefore, a system to dispose the waste while minimizing contact is needed.

3. RESEARCH METHODS AND PROCESS MODEL

3.1. Research Methods

As previously discussed, conventional studies were focused on the policy plans, infection within hospitals, and infection prevention technologies. However, as raised through the MERS outbreak in Korea, the establishment of a systematic management system focused on the entire process of the spread of an infectious disease is considered to be needed. Based on such needs, an in-depth interview was conducted with 10 infectious disease experts in medical institution in Korea from January 15, 2016 to February 15, 2016. Limiting the scope of infectious disease to the one that flows from a country to the other country, an interview was conducted with respect to the critical point when the spread of infectious disease can be minimized, and the following process model was designed on the basis of the derived results.

3.2. Process Model

In general, a journey map is defined as a story and process that unfolds relationship between users and services (or system, product, brand, institution, etc.) in a chronological order. In this study, the entire process of the spread of infectious diseases is to be systematically analyzed using the characteristics of a journey map that allows viewing the entire process chronologically. According to the results of in-depth interviews with experts derived from 3.1, the life cycle from the entry to the eradication of an infectious disease was divided into 5 stages as shown in <Figure 1>. Each point of quarantine at airport, transportation, medical institution, self-isolation, and waste disposal is considered to be a critical moment to minimize the spread of the infectious disease. Since a proper system is needed in this whole process of the life cycle, we intend to suggest the ICT that can be utilized for each process.

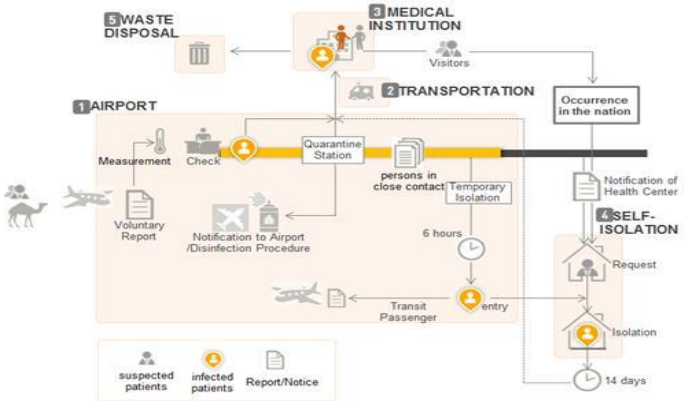

Figure-1. Process Model using Journey Map
Source: Author's data

4. PROCESS ANALYSIS RESULTS

Table-2. ICT-based infectious disease management system

Stage	Improvement Plan Using the ICT	Improvements
Airport	Gantry-type body thermometer	High-accuracy, non-contact
Transportation	Ambulance Location Monitoring System	Information quickly available
Medical Institution	Access control using RFID	Prevention of the secondary infection through isolation
Self-Isolation	Temperature measurement using an wearable device	Systematic self-management possible
Waste Disposal	Autonomous vehicle	Prevention of the secondary infection by minimizing contact

Source: Author's data

4.1. Process 1: Airport

Since the quarantine stage for the entrants at the airport needs a system that can identify the primary suspected cases by examining the entire travelling people, we propose a Gantry-type body thermometer. It enables quick identification by detecting each traveler's body temperature when they pass through the Gantry as shown in <Figure 2>, and is a non-contact safe system. It is expected that the introduction of such a system will allow the primary suspected patients to be quickly identified and the measures to be taken.

Figure-2. Gantry-type Body Thermometer
Source: Topteches

4.2. Process 2: Transportation

Once diagnosed as suspected cases, the patients are transported to the hospitals, and subsequently, the information of ambulances located nearby and available is needed. Therefore, we propose the Automatic Vehicle Location System for Ambulance (AVLS). AVLS is a system equipped with GPS and wireless communications, and can identify relevant information such as current location of the ambulance, managers, and vehicle operation in real-time. It is considered that the introduction of such a system will enable the sharing of accurate and prompt information, and systematic management.

4.3. Process 3: Medical Institutions

Visitors, patients and hospital staff are the subject who need to be particularly controlled in order to prevent the influx and spread of infectious disease. Particularly, visitors are the main factor in spreading an infectious disease as major users of the hospital. Therefore, we propose an access control system that allows only authorized people to have an access by distributing the ID card equipped with RFID technology at the hospital entrance. In some overseas hospitals, the visitor-only gates are installed and operated for the control of the visitors as shown in <Figure 3>. As analyzed in the MERS outbreak, the contact between people is one of the main factors of the spread of the infectious disease. It is expected that the introduction of such a system will reduce contact and thus minimize the spread of infectious diseases within hospitals.

Figure-3. Access Control System
Source: Thomas Jefferson University Hospital

4.4. Process 4: Self-Isolation

Although the patients in self-isolation are isolated, the measures to maintain day-to-day life are needed. Also, in order to prevent the omission of the measurement, record and report of body temperature of the self-isolated patient, a method that can automate this process and enable prompt checks and actions online is required. We propose to build a system to measure the body temperature using a wearable device and report it automatically. Wearable devices capable of measuring temperature have already been launched in Korea. It is considered that the introduction of such a system will be a way to easily and systematically manage the self-isolated patient, and enable quick actions to the patient should anything goes wrong.

4.5. Process 5: Waste Disposal

We propose the introduction of an autonomous vehicle to prevent the exposure to the waste during the course of waste disposal. Autonomous driving is a technology that enables a vehicle to drive a fixed route autonomously or move to a pre-determined destination with a navigation system using GPS and Wi-Fi by autonomous driving. Hospitals occasionally use an unmanned vehicle system during the transportation of hazardous materials or the meal transfer. In addition, the commercialization of autonomous vehicles and related services are recently under intense development. It is considered that the introduction of such a system will be able to prevent the secondary infection by minimizing contact in the process of the waste disposal.

5. CONCLUSION

Although the MERS outbreak in Korea could end with less damage, the inadequacy of the responsive measures led to greater damage. Under these circumstances, this study is aimed at establishing systematic counterplans to infectious diseases by presenting a new infectious disease management system incorporating the ICT. ICT technology in Korea is at very high level, evidenced by 'ICT development index' of Korea which was ranked No.1 in the world in 2015 (Yonhap News, 2015). Thus, it is considered that an effective infectious disease management system can be constructed by the introduction of high-level ICT.

This study has the following implications.

First, this study presented a journey map to generally analyze the life cycle of an infectious disease, and was conducted on an effective infectious disease management system through the introduction of ICT technologies to each stage of the process. This study has a significance in that it attempted a new research on an infectious disease management system from the process-centered perspective that had never been adopted.

Second, the accurate and timely sharing of information at each step and close collaboration are required in order to effectively prevent the spread of infectious disease. It is believed that the introduction of the ICT will enable this.

Third, among the proposed technologies for each step, the stage that can incorporate the technology and will show a visible effect in the shortest time is considered to be the self-isolation. The self-isolation stage has been under human management in the existing infectious disease management system. Wearable devices that can be introduced immediately are commercially available, and this is considered to achieve a large effect.

The outcome of this study will be an effective management system to prepare us for the possible second and third MERS outbreak that may occur at any time again, and is expected to present a new convergence direction of the ICT. This study has limitations of mainly investigating the cases in Korea, and further studies on specific ways to incorporate the technologies will needed in the future.

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