



## A RESEARCH ON THE IMPLEMENTATION OF AN ICT-BASED ENTRY AND EXIT CONTROL SYSTEM TO PREVENT HOSPITAL INFECTION

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### ABSTRACT

Recently as contagious diseases such as SARS and MERS etc. have been widely spread across the globe, there is an increased emphasis on the importance of infection management. As hospital infection has been pointed out as a critical issue factor, the need to implement a disease control system in order to control infected patients is becoming necessary. Because hospital systems are information dense systems, utilizing ICT (Information and Communication Technology) and convergence technologies such as RFID (Radio Frequency Identification), Smart Devices, and LBS (Location Based Service) etc. are being proposed as the main methods to implement this system. But because previous research combining hospital data and the area of IT convergence, mainly conducted research with the objective of OA (Office automation) and MIS (Management Information System), there is a limitation of this previous research to be applied to infectious diseases and disease management. To address this, through in-depth interview with professionals, the entry routes of diseases into hospitals were examined and a method to prevent this was proposed in this research. The results of this research confirmed that to prevent diseases from entering a hospital, the most important factor was to increase the access layers of entrance of a hospital to control points of contact. Based on these results, an ICT technology that could be implemented in layers was proposed. It is expected that the results of this research will be helpful to managers and staff of hospital organizations that need to implement control systems to prevent contagious disease infection in hospitals.

**Keywords:** Disease control system, Contagious disease, ICT (Information and Communication Technology), RFID (Radio Frequency Identification), LBS (Location Based Services), Contagious diseases.

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### Contribution/ Originality

This paper's primary contribution is to help effectively prevent contagious disease spread by the combination of ICT and administration system of disease. This study uses an expert interview to investigate key issues.

## 1. INTRODUCTION

Recently as a result of the development of hospital infection disease management ICT (Information and Communication Technology) and of the acceleration of convergence of information and communication technologies, there are rapid changes in the management systems and structures of hospitals. In addition, with the

occurrence of diseases such as SARS, new flu epidemics and MERS etc. across the globe, it is expected that there will be new changes in hospital disease infection management systems.

To explore the management methods of infectious diseases, there is a need to examine through what routes diseases spread. The main routes through which infectious diseases spread are direct contact with a patient and also through direct and indirect contact with airborne germs from coughing or spreading through the respiratory system of patients or through contaminated objects. Therefore, it has been pointed out that many of the patients are relatives of the patient or people who come into contact with the patient, and medical personnel and staff that treat the patient etc. Hospital Infection was a term first used in the 「Infection Management in a Hospital」 published by the American Hospital Association in 1968, and the Centers for Disease Control and Prevention (CDC) defines hospital infection as a disease that did not show symptoms and was dormant when a patient was hospitalized, but a disease that shows symptoms and becomes infectious during hospitalization or after discharge. While hospital infection is most common for hospitalized patients, it is not limited to patients and can occur in nurses, doctors and other hospital staff and even visitors etc (Young-Hee, 1995; Woo-Joo, 2002). When analyzing the actual infection patterns of MERS patients in Korea, it can be confirmed that the number of infected people who were care providers comprised up to 40% of infections (Yoon, 2015). Even in the case of exogenous hospital infection, the chance for infection of patients with a weakened immune system that is exposed to the pathogenic bacteria outside of the hospital increases (Woo-Joo, 2002). In other words, the main target in preventing the spread of infectious diseases should be set as medical institutions, and a method to control contact with infected patients within a hospital is presented as a major issue (The Korean Society of Infectious Diseases, 2015).

As hospital services converge with ICT, the movement routes and patterns of patients, medical staff and other hospital staff and visitors can be controlled and managed, and this is being focused on as an alternative to prevent the spread of infectious disease. After the MERS epidemic, pre-emptive quarantining of patients with respiratory system symptoms, the need for a space to first diagnose patients, controlled access of all people entering and exiting medical institutions, and the need for a record log of all people entering and leaving were emphasized as response measures (Tae-Hyong, 2015). Up to now ICT was used in general for administrative tasks related to the hospitalization, discharge, various testing, prescriptions and billing etc. of patients and storage and communication systems for hospital records, clinical decisions support, deciding order for hospitalization and storing medical files (Coiera, 2003). But in the future, it is expected that not only hospital administrative tasks but also preventing the spread of infectious diseases using technology can be provided using RFID, Smart Device, and LBS technologies etc.

Therefore, this research has the objective of proposing the implementation of a system that can control the movement of patients, hospital staff and visitors by research possible utilization methods of ICT within hospital to prevent the spreading of infectious diseases. This research study is expected to provide a practical perspective on implementing ICT convergence infection management systems by serving as foundation research for more in-depth future research on the entering of infectious diseases in hospitals and infection prevention.

## 2. RESEARCH DESIGN

### 2.1. Categorization Criteria and Research Scope of Medical Institutions

According to the medical laws of Korea, hospital grade medical institutions are medical service institutions that provide medical services to hospitalization patients mainly by doctors, dentists and Korean Medicine Doctors, and are categorized into hospitals, dental hospitals, Korean Medicine hospitals, convalescent hospitals and general hospitals. (Medical Law Section 3) This categorization can be divided in more detail into hospitals, general hospitals

and upper tier general hospitals, where hospitals must have more than 30 sickbeds or more than 30 convalesce beds. (Medical Law Section 3 Clause 2) General hospitals must have more than 100 sickbeds, and when there are more than 100 and less than 300 sickbeds, these hospitals must offer at least 3 services out of internal, external and pediatric and young adult medical services, and must include a total of at least 7 services that additionally include medical imaging, anesthesiology services, laboratory testing and pathology services while a specialist for each medical service must be employed. For hospitals with more than 300 sickbeds, there must be a total of more than 9 services offered out of internal, external, pediatric and young adult medical services, gynecological, medical imaging, anesthesiology, laboratory testing and pathology, and mental health and dental services while a specialist for each medical service must be employed. (Medical Law Section 3 Clause 3) For upper tier medical organizations, the Minister of Health and Welfare designates general hospitals that meet the requirements while also provide high quality professional medical services for severe medical treatment and disease areas. (Medical Law Section 3 Clause 4) General Hospitals are both public interest institutions that also must generate a certain amount of profit in order to sustain a planned future roadmap (Myung-Jin, 2012). Therefore, this research study designated general hospitals and higher tier hospitals for the target of this study by taking into consideration public interest and profitability etc.

## 2.2. Criteria for 'Close Contact'

The criteria that Korea adheres to for 'close contact' is a translation of the criteria set forth by the US Centers for Disease Control and Prevention, and defines close contact as medical staff, relatives and people that have come into within 2m of infected patients, and also people have come into direct contact with bodily fluids that have the chance of infecting. After epidemiology testing, the criteria of close contact of the WHO (World Health Organization) defined all medical staff, relatives, and people that stayed or lived in the same space that came into contact with the patient for the Middle East SARS epidemic. After the 2013 MERS epidemic, the WHO revised the definition of direct contact in 2014, and expanded the definition compared to 2012 to include all medical staff and visitors that had directly seen the patient, all people who had been in the same room, and people in nearby buildings and people who had traveled with the patients and also people that had used the same room (Byung-Chul, 2015). Because close contact is a monitoring criteria for infectious disease management, it serves an important role in infectious disease management. Therefore, this research study selected to use the more inclusive group of close contact people according to the WHO criteria.

## 2.3. Research Issue and Research Method

This research study has the objective of determining the entry route of infectious diseases into a hospital, and to examine methods to prevent the inflow. This research especially focuses on possible ICT technologies that can be applied. The specific research issues are as follows.

[Research Issue 1] What areas and factors must be considered when controlling an infectious disease within a hospital?

[Research Issue 2] What ICT technologies are there for controlling injection diseases for each of these areas and factors?

For our research purpose, we conducted expert interview. Expert interview consists of 2 parts, which are medical center, and information technology. Interview was conducted from Jan 15, 2016 to Feb 15, 2016. Total of 6 experts were interviewed (3 from hospital staff, 3 from Industry). The opinions of these professionals is not only significant because they work in the various industries of medical services, health, management and information technologies etc., but also because they make it possible to provide user focused ICT based health and medical services.

### 3. ANALYSIS RESULTS

The hospital entry and exit process can be broadly divided into two processes. The first is the entry area, which is the step of a visitor, patient or hospital staff going through the hospital entry process when accessing the hospital. The second is the entry to rooms in the hospitals, which include hospital rooms, offices, bathrooms and visiting rooms etc.

To prevent infectious diseases from spreading, the areas where ICT can be applied are broadly the entry and exit areas and the hospital room areas as shown in [Figure 1], and the technologies that can be applied and their characteristics are summarized in [Table 1]. Previous hospital entry and exit processes have limitations that once someone enters the building there are no additional control measures before entering and that tracking and monitoring movement within a hospital is not possible. Therefore, by further dividing the process into entry and exit management, entry and exit control and divisions of space and by utilizing RFID technology, methods to control and track targets is proposed.

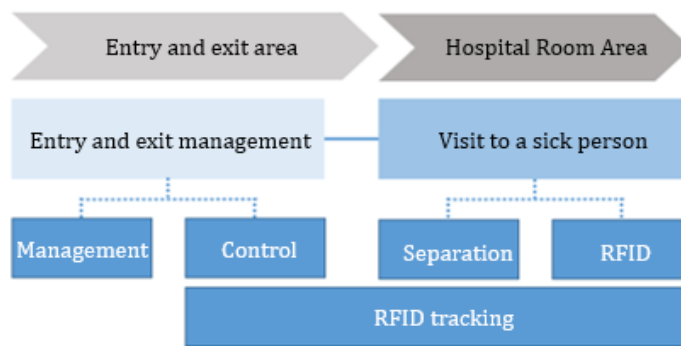


Figure-1. Hospital Entry and Exit Process

Table-1. Distinction of Management Areas and Possible Applicable ICT Technologies

Managed Area	Managed Factors	Objectives	Possible Technologies
Entry and exit area	Entry and exit management	Register entry and exit pass	IR, RFID
	Control entry and exit ways	Entry and exit recognition sensor gate	Control Automatic gate
	Monitor body temperature	Monitor temperature for each person	IR, sensors, Gate methods etc.
Hospital Room Area	Separate visiting spaces	Separate visitors and patients	Physical separation of space and video screen visiting
	RFID Tracking	Monitor and manage movement situations	RFID Detector

Source: From Variety of Reports and Papers

Table-2. Entry and Exit Pass Technology

Method	IR Method	RFID Method
Advantages	<ul style="list-style-type: none"> <li>no electromagnetic interference</li> <li>long life due to low power consumption</li> </ul>	<ul style="list-style-type: none"> <li>no need for internal power source</li> <li>possible to manufacture in various shapes</li> <li>communication possible with attached to body</li> </ul>
Disadvantages	<ul style="list-style-type: none"> <li>shielding effect causes by physical objects and obstacles</li> </ul>	<ul style="list-style-type: none"> <li>short communication distance</li> <li>If the output signal of the Reader is large, there is concern the electromagnetic waves can cause interference with medical devices</li> </ul>
Points to Consider	<ul style="list-style-type: none"> <li>must wear on outside of body</li> </ul>	<ul style="list-style-type: none"> <li>need to establish area of operation for communication within a limited space</li> </ul>

Source: From Variety of Reports and Papers

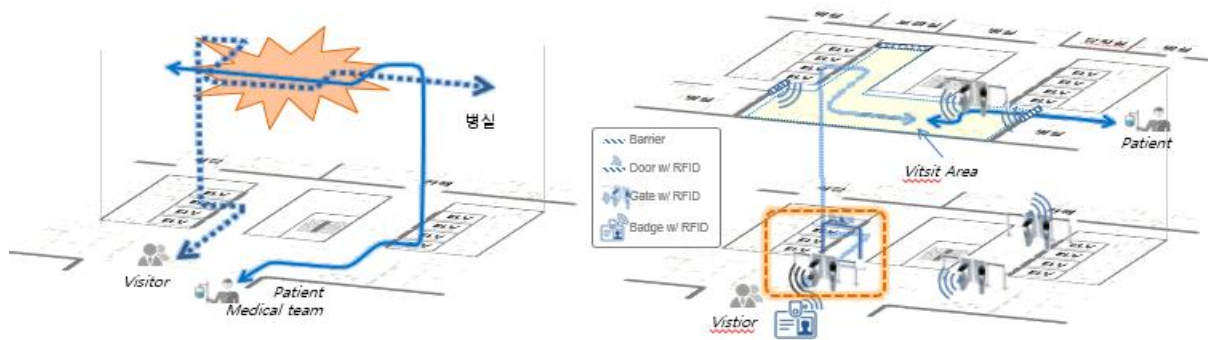


Figure-2. Entry and Exit Management and Control System

#### 4. POSSIBLE TECHNOLOGIES FOR EACH AREA

##### 4.1. Entry and Exit Management and Control

Communication must be possible when attached to the inside of hospital uniforms due to the hospital environment, and for normal operations there must be minimal operational errors. Therefore, as shown in the comparison between the IR method and the RFID method as shown in [Table 2], the manual method of RFID is appropriate from a technological standpoint. The use of RFID entry and exit passes which can be applicable everywhere can distinctively recognize the process of visitors and hospital related personnel approaching and accessing the hospital, and the entry and exit passes can be used to monitor the movement routes as well. At entry and exit control areas, there is a need to control access between areas based on the level of access programmed into the RFID entry and exit passes by implementing a Role-based Access Control system. Also by installing Gantry type body temperature thermometers at access gate areas, primary patients suspected of symptoms and infection can be monitored. In order to decrease the negative implication of these body temperature thermometers, there is a need for adequate information and awareness of these devices and to reflect user experience into the design and implementation.

##### 4.2. Space Separation

As MERS showed an unexpectedly high ability to spread, the WHO cited the issues of suboptimal infection prevention and control measures in hospitals and the custom of many visitors or family members staying with infected patients in the hospital rooms facilitating secondary spread of infections among contacts. As a countermeasure to infection by the hospital and to address the need for a separate space to visit patients and to improve overall hospital culture and experience, a separation of visiting spaces is proposed. As an issue that needs to be taken into consideration during the design of a hospital, by implementing an isolated space between visitors and hospital patients, there is a need to make available a space where only permitted people are allowed to enter and exit. When coming into contact is deemed to be impermissible, a mixed reality based telepresence video visitation system can be proposed as an alternative. Video conference visitation based on mixed reality means using a HMD (Head Mounted Display) based on See-through technology to output 3D forms to a location that is desired and suitable for users in remote locations.

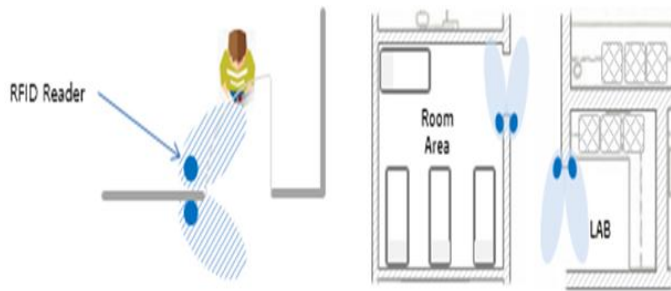


Figure-3. RFID Reader



Figure-4. Monitoring System

#### 4.3. RFID Tracking

Location tracking technology using RFID can determine current location and entry and exit access based on communication between RFID entry and exit passes and readers that are installed throughout the hospital. Previous methods installed readers before and after entry and exits ways as shown in [Figure 3] to detect approach, entry and exit. There is a need to install readers with tracking functionality based around the major activity points of a hospital, which include entrances to hospital rooms, restricted access areas and hallways etc. Also the information collected through RFID readers that are installed at important locations as shown in [Figure 4] can be rendered as a layer on top of the entire floorplan of a hospital to check and monitor real time location. Development of the 5G technology is expected to enable the realization of new service (Sang-Hoo, 2015).

### 5. CONCLUSION AND SUGGESTIONS

As infectious diseases occur around the world, the importance of hospital infection management is increasing, but there is a severe lack of research in the area of preventing infection in hospitals. This research study examined the current state of hospital infection and analyzed the inflow route of infectious diseases to a hospital, and deduced the appropriate ICT technologies that can be applied to prevent infection and spread of disease. The results of analyzing the inflow route of infectious diseases to a hospital was concluded that the close contact patients as defined by the WHO were a main factor. Therefore, to prevent infection and spread of diseases hospitals, the importance of controlling the movement pathways and primary diagnosis of people entering and exiting medical institutions was confirmed. The entry and exit process of hospitals was examined by breaking down the entry and exit processes of a hospitals into entry and exit management, entry and exit control, space separation and RFID tracking. Entry and exit pass registration at the entry and exit management process and implementation of RFID based entry and exit control areas to correctly determine a list of people entering and exiting was proposed. Later using entry and exit passes using RFID and Gantry type body temperature thermometers, people entering and exiting can be monitored and controlled.

By separating the visiting space and making an independent space where people from outside the hospital come into contact with patients in the hospital room area is provided as a method to prevent infection and spreading of disease. It is possible to implement RFID technology so that only people with entry access can enter. In the event that it is determined that visitors and patients should not come into contact, a mixed reality based service is proposed as an alternative. It is possible to implement RFID tracking technology in most areas that need to be managed. It is possible to restrict access to specific areas using RFID readers, and even when entry is permitted, because entry and exit times are logged, this technology has an advantage that tracking in the future is possible. Also the information collected through the RFID reader can be rendered as a layer on top of the entire floorplan of a hospital to check and monitor real time location. Because the target for this research was limited to medical institutions above the general hospitals tier, there is a limitation of this research in that it cannot be implemented at

all medical institutions. Also because the approach from this research was from a public interest perspective, this research has limitations in that there is no examination into how profitability will be influenced. However, this research is significant in that it provides a preliminary examination into the convergence of ICT with the prevention of disease infection in hospitals. When hospital infection prevention technologies converged with ICT are implemented in future research, the results of the degree of influence that ICT technologies have on each step of the process is an area of research that should be looked forward to

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