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## The Development of RFID in Healthcare in Taiwan

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### ABSTRACT

Healthcare industry has unique characteristic about human's life. Any mistake or medical error will cause the irretrievable regret. Patient safety is the most important issue in recent years. Because the uncertainty of disease occur, the demand of healthcare need, location and types are changed frequently. By the pressure of "Self Management Plan", how to make limited healthcare more effectiveness and efficiency is critical for survival. Radio Frequency Identification (RFID) can be able to provide to identify, tracking and tracing for patient or medical objects directly and continuously. RFID is made object wisdom and process automation. It debase the cost of collect data from first-line in tradition MIS.

RFID in Taiwan is more famous. There are four kinds of applications in healthcare industry. Some of them will be the killer application when government's policy trigger and industry full-scale implement in the future. There are six hospitals deploy RFID in pilot plans by government support. And there are still some necks of bottle in deployment. The research assisted by foreign research and extracts by the experience in expert interview. We point out the critical deployment factors by five dimensions, including: system technology (system readable rate, frequency limitation, instrument interference & Human healthy, and transmission distance), system cost, common standard, health industry infrastructure and system integrate, and the issues in privacy and security by patient. The future research tries to find out the total solution to deploy RFID in healthcare industry to build up the "patient safety healthcare environment".

**Keywords:** Radio Frequency Identification (RFID), patient safety, healthcare industry, medical error, bar code

### 1 INTRODUCTION

Healthcare industry is related to the person's life closely. Any mistake or medical error will cause the irretrievable regret. Longer work time and work pressure made medical errors and negligence often happened in Hospitals. Healthcare is a high human concentrated industry. There are a lot of team works and coordination together from emergency medicine, outpatient care and inpatient care in hospitals. The report of Institute of Medicine (IOM) in "To Err is Human-building a safer health system" indicates that medical error often happens on bad communication and artificial negligence [6].

Patient safety is the most important issue from World Health Organization (WHO), European, America and other nations in recent years. After experiencing the storm of SARS, beating the wrong needle and giving the wrong drug...etc. The healthy quality and patient safety subjects are more valued by the public gradually. "Department of Health" considerably pays more attention to patient safety, and announces five execute goals in annual plans for government policy in 2004 [2].

Healthcare industry has his unique characteristic. Hospital is a place that people care of people. The healthcare service can't save and shift. Because the uncertainty of disease occur, the demand of healthcare need, location and types are change frequently, so the maximum difference between healthcare and others

industry is the uncertainty of medical demands [5]. There is high inside knowledge and entry barrier in healthcare industry. Computerized systems have capacity to augment the physician's capabilities to reduce the error rate for the advantage over humans, include: never forget, never get tired, and make no mistakes [8].

Hospitals in Taiwan had long history and abundant experience to import Hospital Information System (HIS) and Electronic Healthcare Record (EHR) with IT. But, there are more competitive and high pressures in hospitals in Taiwan by the limited income for healthcare insurance in "Total amount payment method", "Self Management Plan". How to deploy information technology IT to assist specialists in hospital working more effectiveness and efficiency to increase capability in limited medical resource and control operation cost cautious are the most famous research issues to the scholars in healthcare information management and healthcare service management [1].

Now, HIS can purely support work for operation level or management level. But, the most bottlenecks to implement information system in hospitals is that HIS can't handle the information about object name, time and location correctly including medical workers, patients and pharmaceuticals. Then it's hard to advance the capability for HIS to statistics, analysis and decision support, even more than strategy level.

Radio Frequency Identification (RFID) is one of the top

ten technologies in this century [14]. RFID is a kind of wireless technology by using radio frequency (RF) to identify objects. RFID can be able to provide to identify, tracking and tracing for patient or medical objects directly and continuously [1]. The characteristic of RFID is made object wisdom and process automation. RFID can reduce the cost of collect data from first-line in tradition MIS and have dramatic potential to great efficiency and profit in supply chain management (SCM) from manufacturer, logistics to retailer [4].

RFID can decrease medical errors, promote healthcare quality, and make the healthcare process automatic and optimize to save amounts of work in data collection, entry, integrity and confirmation such as patient identification, the three reads and five checks when giving pharmaceuticals, the data exchanged by patient referral...etc. By the characteristic of PPI (Positive Patient Identification) and POC (Point of Care)[16], RFID technology makes the maximum effect on HIS to deliver information at right time, real time and any time by reduce the time in data entry, object identify and make healthcare process visibility.

RFID is not a new technology, but it's a new revolution for application. By the same standard, protocol and communication language, there will be a strong impact for our life. Like the evolution for geographic commerce, electronic commerce (EC), mobile commerce to ultimate commerce, there's also extend to "U-healthcare" [21]. There are 4U in healthcare which includes: "Ubiquity" healthcare and service, "Uniqueness" EHR, "Unison" information and patient integration, and "Universality" healthcare environment. RFID provides "Competitive Intelligence" to decision maker and makes "Quick Response (QR)" for healthcare market demand.

## 2 RFID IN TAIWAN

RFID in Taiwan is more and more famous. Taiwan government provides both reward and investment by "Ministry of Economic Affairs" (MOEA). The substratum of administrations in MOEA are "Department of Commerce", "Department of Industry Technology", and "Industrial Development Bureau"[30]. The direction of policy in "Council for Economic Planning and Development to president" and the conclusion in "Science and technology Advisory Group of Executive Yuan" in "2003 SRB (Strategic Review Board ) meetings" also promote RFID to an advance and significant development in Taiwan[23].

The "Executive Yuan" (the Cabinet) in Taiwan promulgated "The vision in Taiwan of strategy service industry in 2010". MOEA established a cross-division RFID promotion team. The three important guide lines are "The Alliance of Supply Chain, (S plan) ", "The research and application in RFID platform, (R plan)" ,and " Telemetry, Health tourism, Integrated

medical system in Healthcare , (THIS plan)" [23].

There are different RFID industry orientation in different core development fields. RFID industry can discriminate in five divisions: RFID Tag (chip/die, antenna, attach, testing, convert), Reader (RF circuit design, digital circuit design, API development, and antenna module), Middleware (like SUN), System Integration (like IBM), Application Software (like Oracle), and Consultant (like Auto-ID lab).

Taiwan has maturely knowledge for RFID in semiconductor design, memory design, and specialized wafer production, electronic fabrication, software development, and system integration. Wireless and communication industry provide the capability of RF design, antenna design and field testing. Automatic equipment industry also possesses packaging and testing ability to cost down and increase production [19].

"Executive Yuan" formed RFID technology research and industry application alliance include six special interest groups (SIGs) in Taiwan, including with: Pcess equipment and Mterial SIG, Design and Mnuufacturing SIG, System Integration SIG, Supply Chain SIG, Testing and Certification SIG, and Industry Information SIG [32].

Many foreign information corporations also build up RFID research centers in Taiwan by the "International Innovation and R&D Base Plan" in "Challenge 2008-National Development plan" [22]. The enterprises include Oracle, SUN, HP, and Microsoft...etc. One of Auto-ID labs is in Fudan University, Shanghai. Two sites cross-strait of China are the main base of manufacturing center for foreign corporations. There will be many RFID technology developments and success application to paradigm shifts both in china cross-strait in nearly future.

## 3 RFID IN HEALTHCARE

### 3.1 The trigger of RFID in healthcare

There are no issues more important and popular than patient safety in Taiwan or foreign abroad. HIMSS patient safety survey indicates bar codes and CPOE (Computerized Provider Order Entry) have potential to improve patient safety [15]. Frank Kuo indicate five applications of RFID to increase patient safety by the famous seven patient safety goals in JACHO 2004, which including blood management, drugs management, surgical operation management, infection management, and medical equipment management [2]. RFID can also provide functions to satisfy three main demand of FDA's 21<sup>st</sup> century approach to patient safety like automatic data collection; partnerships with other entities (government agencies, healthcare providers, and payer organizations); and enhanced communication[26]. Wal-Mart requests the providers of front hundred

pharmaceuticals must deploy RFID in package with EPC standard, Read-Write passive tag (class2) before January 2005[27]. Accenture Technology Lab makes up the alliance of the biggest of eleven pharmaceutical manufacturing, distributions and hospitals [9]. Healthcare Distribution Management Association (HDMA) who constructs the health products and distribution standard to order that every pharmaceutical must paste RFID tag by case level of pharmaceutical in 2007[33]. The regulations of the "Food and Drug Administration (FDA)" in USA are even stricter to item level [27].

The specially report of "ID TechEx" estimate the application market of healthcare in America medical industry in 2010 will be arrive at \$ 86.3 billion[29].By the above of the pharmaceutical supply chain with RFID, it's a trigger to detonate a great quantity of the downstream hospital implement RFID. So the questions of hospital aren't either or not to deploy with RFID, that is when to do it? [20]

### 3.2 The development in healthcare in Taiwan

The development of RFID in Healthcare in Taiwan is just at the initiation stage. There are six hospitals proceeding to RFID pilot plans earlier by government support. The pilot development goals of them are patient identification, drug identification, contact history tracking, infection announce, and medical warehouse management [1].

During SARS period, "Ton Yen General Hospital" deployed RFID pilot plan which technique support by "Industrial Technology Research Institute (ITRI)" at the first. And then, "Taipei Veteran's General Hospital", "Taipei Medical University Hospital", "KFAYA cancer center", "Show-Chwan Healthcare System", and "Tri-Service General Hospital" proceed RFID plans by government support[34,35,36,37,38,39].

"The Promotional Committee of e-Business Standard in the Medical Industry" builds "the Common Trade Platform in the Medical Industry" by "E-Commerce counsel plan" in MOEA. Taiwan wants building pharmaceutical data exchange standard and environment by XML and web service to promote RSS (Reduced Space Symbology) and CS (Composite Symbology). The committee will try to integrate EAN.UCC standard to healthcare industry [25].

The development directions and application fields with RFID in healthcare can division into four parts:

#### (1) Biotechnology and Pharmaceutical Fields:

Chemical reagent tracking, Animal, cell, and patient tracking and compliance in clinical trails.

#### (2) Medical Supply Chain:

Pharmaceutical supply chain, Warehouse management,

Anti-counterfeiting, Blood bank management, and Monitoring radioactive isotopes. (Including drug and surgical dressings)

#### (3) Hospital Internal Management:

Patient identification and position, Drug compliance, Disease control, Coordination the medical device, and Clinical path optimization.

#### (4) Healthcare Service:

Disease control, Emergency medicine, Sensors and Telemedicine, Long-term care, and Community continuity care.

## 4 THE EXPERT INTERVIEW

RFID implement in healthcare still in initial stage. There's no ready case or completely success experience in healthcare. We proceeded depth expert interview by quality research method with 10 experts, which including chief of the hospital information department, and scholars with RFID research in healthcare information, and health service management in Taiwan. We find out the advantage and inferiority in RFID in healthcare.

After expert interview, we integrate, sort and analysis the view and opinions in expert. The mainly critical key point to deploy RFID in healthcare industry can be classified into five followings: System technology, implement cost, standard protocol, information infrastructure, and privacy protection. We discuss them as follows:

### 4.1 System technology

#### (1) System readable rate

The most special features of RFID system lies in non-line of sight. Radio frequency delivering in air-interface needs better channel coding and modulation to reduce the signal broken and noise. Currently the readable rate of RFID system can't reach 100%, and this also becomes a biggest obstacle to implement. There are a lot of primary factors which influence the system readable rate, including: the direction of transmission, air-interface, the characteristics of product, and the characteristics of operation (environment).

The electrical label and reader have the directivity so there is extreme difference on the reading angle (horizon, vertical, oblique). If the product was horizontal between each other and outward to the product, it could be improving the readable rate. In other words, these critical factors such as temperature, humidity, and electromagnetic interference (EMI) of external environment should be paid a lot of attention. On the other hand, if the electrical label is put on the counter of absorbent or metal that would be decreased the readable rate substantially. The other reasons that

make the low rate of reading such as the distance of transmission and the moving speed of tag.

Besides, distance, indoor environment, the design of antenna, and the direction of installing are also very important influence factors. We can't use the high power reader in hospitals. Therefore, while implementing system, they should depend on the electric wave strength, clinical path, the need of moving line, and the result on-the-spot test which make they decide the demand and the position of readers. So, to deploy RFID isn't only a technology, it's an art and experience.

## (2) Frequency limitation

The wireless channel belongs to the public wealth. The International Telecommunication Union (ITU) is all carried on the programming and allotment of the frequency application by the government supervisor organization. Using RFID hardware equipment needs passing license by the "Ministry of Transportation & Communications" in "The Directorate General of Telecommunications (DGT)".

There are open frequency in the industry, about scientific and medical (ISM) in 13.56MHz, 2.45GHz. Currently, 915MHz is a controlled radio frequency, but the Directorate General of Telecommunications (DGT) has already declared the end of the year will open the 922-928 MHz channel to provide the RFID usage in the end of the year [16].

## (3) Instrument interference & Human healthy

It is the most anxious reason that radio wave interferes of medical instruments interactive, and it also influences weak patient in the medical environment, too. The conclusion of FCC and IEEE didn't find out any evidence that "Non-Ionization Radiation" of the normal regulations usage will endanger the human body. But nobody and no research guarantee about it.

On the interference of the medical instruments, we need to advance the demonstration first before implementing RFID in hospitals. Then, we carry on ducting into the work and field-test. Hospitals can aim at first: Electric shock machines, electrocardiogram (EKG), breath machines, and IV Pumps etc equipment carries on the test, and measures its wireless delivers the data mistake rate (BER) and electromagnetism mutual interference (EMI) condition. Currently hospitals which have implementing RFID all did not find obvious influence. However, the telecommunication bureau and department of Health supervisor organization should ensure safety to relieve the misgiving by more professional research [12].

## (4) Transfer distance

The factors which influence transfer distance include: reader power, sensitive of RFID tag, and four factors above-mentioned that influence about system readable rate. There are two kinds of RFID tag type is passive

and active. Active has battery by itself, but passive hasn't. Under the common testing environment, the distance of passive tag of 13.56MHz is approximately 1m, and 915MHz (UHF) is about 5m; the distance of active tag that the 2.45GHz (Microwave) is about 3m. The active RFID tag with 915MHz can transfer close to 100m.

## 4.2 Implement cost

Recently, there are some developing hamper in the other industry, main reason is higher cost. Healthcare has strong relation with persons' life and any mistake or medical errors may cause the irretrievable regret to patients. Medical errors will be impact hospital's brand and decrease customer's confidence violently. Furthermore, Healthcare should belong to public-spirited wreath in nations, it should be considering how to value added in society, not just to earn money. Medical institutions need to promote medical quality, decrease medical errors, and raise working efficiency with sacred spirit. The potential benefit and reality must evaluate altogether.

But RFID tag cost still influence spread tempo. The method of production and the market scale of RFID are the key factors to cost down. Just like the noted question about "Chicken birth eggs first, or contrariwise egg result chicken." Auto-ID estimate at the threshold limit price is \$5 cents. But, the price of purchasing in market is still around 40 cents (or above). Taiwan government announces that "Quanta Computer" can already production RFID tag around \$5 cents [11].

Like the statement to implement EMR, and HIS before, the cost of maintain always be extreme high than initial deployment expense. When hospitals evaluate to deployment RFID, they should be realized the capability, function, budget, and characteristics of their demand. To ask for advice with consultation is greatly important.

## 4.3 Standard protocol

There is long history in RFID, and many nations had already established their standard specifications for RFID, such as ITS America, U.S. Department of Defense, AIDC, ISO, ANSI, and CEN...etc. Because EPC network has the special feature such as automatic data exchanging, it extensively applied in general so far. The standards such as the computer network infrastructures of EAN, UCC, and MIT Auto ID Center propose EPC Network. The standard of EPCglobal includes the coding structure on tag, air-interface, local interface, Savant, Physical Markup Language and the Object Naming Service (ONS) together with the Savant support network [24].

In the aspects of foreign medical industry, Health Industry Business Communications Council (HIBCC) establish common standard protocol of the medical care

environment and the protocol can communicate with ANSI, CEN, and HIBC[28]. Currently the domestic medical hospital has no common standard. However common coding format, it appears that data interchange among different HIS is more important at medical institutions. This needs the Department of Health and related supervisor organization to establish it as soon as possible.

#### 4.4 Information infrastructure

The complete infrastructures is a cornerston to deploy RFID well, including : the network communication with common protocol, Health Information Network (HIN), PML server, ONS server, and the mechanism about audit and authentication, and un-interpolation. On the other hand, the backup mechanism should be established beforehand. Through the high utilization, stability, scalability of server system that can maintain a lot of data file, analysis and process.

By system integration view, the simple close loop system (single hospital inside) can be extended the open loop system (inter-hospitals by alliance). But it will substantially increase system complexity, expenses and timing significantly. However, it's only amplified on more effectively and reach the maximum revenue of investment (ROI) in implementing RFID, when the information infrastructure has been build up completely.

#### 4.5 Privacy protection

The right of privacy here can be divided into medical workers and patients. Medical institutions can control more complete and durable information of members in hospital by RFID, but also cause larger personal controversy of privacy. Medical industry has its particularity. Under the need of safeguarding the whole benefit of social, the public hygiene environment and medical science research etc, personal privacy is not placed into the initiative of position definitely while medical information privacy and personal right conflict mutually.

Besides, the questions in RFID about EMR data ownership, data security responsibility, data expiry date...etc, they also cause many controversies between medical care quality and the power of professional medical treatment from academy such as medical science, law, politics, science, technology and humanities etc.[3] The supervisor authorities should carry on the more thorough study about this, and have definite standard to let medical institutions to follow.

### 5 CONCLUSION

Like the chairman Mao Tse-tung in China who said: "The future is glory, but the road is complicated". And he also said: "Doing right direction, everything will be alright" [40]. To understand the development process

and constrains of RFID technology in healthcare, can let us deploy RFID correctly at right time, right place and right strategy model. Then, hospitals can possess best ROI, make the value added and acquire competitive advantage.

How to promote patient safety are the most important issues in healthcare in Taiwan. To maintain high healthcare quality is not to reach the goal in one step. To error is human. There are not the same reasons in medical error in each hospital. There is less medical adverse event in negligence by artificial to be announcement by hospitals. Now, the questions we aware are just like a nook in an iceberg. However, healthcare industry has unique characteristic about human's life. So there are maybe some "killer applications" in healthcare first. We point out the critical deployment factors by deploying RFID in healthcare. The future research tries to find out the solution to solve the questions in the paper above.

Integrating RFID with HIS will make patient more safety, and make healthcare more accuracy and efficiency, and less medical adverse event in negligence. We create an automatic healthcare mechanism to depend on five rights care quality, which include: right patient, right drugs, right dose, right time, and right route. The final vision is to create the sublime of dream by RFID assistance in the "patient safety healthcare environment".

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