Chapter 6
Smartphones: The Next Generation Medication Administration Tool

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6.1 Introduction

A common aim of healthcare professionals is that patients regain a healthy state under their professional and dedicated treatment. However, the "To Err is Human" (Kohn et al. 2000) report released by IOM (Institute of Medicine) in 1999 emphasized the fact that many patients suffer from medical accidents every year. This report brought to the healthcare domain the concept of "Safety Management" as a medical accident measure, and attempted to ensure "Patient Safety" by the introduction of the ICT (information and communications technology) check system.

The Japanese Council for Quality Health Care reported in 2009 that nurses had the most frequent error incident reports, followed by physicians (Japan Council for Quality Health Care Division of Adverse Event Prevention 2012). Most incidents occurred in the patient's room (inpatients) and the operating room; the most frequent issues were "Bedside assistant jobs" and "Treatment care/procedure". The most frequent reported causes were "neglecting to check", "misjudgment", and "neglecting to observe." The report noted that the number of reported incidents had not changed since 2005. It was also noted that 41 % of medical errors ensued from medication administration (Lisby et al. 2005). Medical safety management in medical practice is still an ongoing issue.

The rising cost of medical technology development has encouraged national interest in "sustainable health services". For healthcare management reform, the focus on information gathering and analysis of EHRs (Electronic Health Records) is a pressing concern. We note the importance of medical safety practices, such as properly documenting medical records, tracking expenditures for hospital business analysis, and ensuring traceability and accountability.

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Medical practice entails forms of consumption and, in this context, the idea of building a mobile medication checking system has emerged. These mobile devices allow the user to take them away from the staff station, enabling the checking of medication order lists and consumed medications at the same time. However, there are many problems peculiar to the healthcare field; trials using mobile terminals with ICT support have a long way to go before being acceptable for medical use. We will give an outline of the background of BCMA (Bar-Corded Medication Administration) (Koppel et al. 2008), introduce some trials on it, and discuss the way forward.

6.2 Issues Relating to BCMA

6.2.1 Institutional Background

In Japan, "The Drugs, Cosmetics and Medical Instruments Act" and "The law to revise the drawing of blood and blood donation business control methods" came into effect in 2005 (Pharmaceutical and Food Safety Bureau 2004). Biogenous medical products, except plasma derivatives, require management of the production history. Not only is a product's history tracked during the initiation stage and during production but the selection of the donor (the source of raw materials) should also be able to be confirmed. In addition, it is necessary to maintain records of antipollution maintenance and manufacturing tracking.

MHLW mandates drug companies to keep detailed records of followup of the donor user, the infectious disease submission report, the mandatory display of primary material if a drug is biogenous product, and the monitoring of proper usage at the post market. Drug companies must make sure that all records are connected and verified to ensure accountability in case of future incident investigation.

Historical background of the constitution of the law was the experience of the lawsuit on adverse drug reactions and the investigation of the casual association between administered drugs and the adverse drug reactions had processed with difficulty because of lacking sufficient records. We recognize that extensive traceability is required in order to undertake root cause analysis into the harmful effects of drugs.

In September 2006, to prevent accidental misunderstandings on drug applications and to ensure traceability, guidelines for implementing medication barcodes were given in office notice No.0915001 "The barcode display on an ethical drug" by MHLW (Ministry of Health, Labour and Welfare) Pharmaceutical and Food Safety Bureau (2006). The ethical drugs were categorized into five kinds: biogenous products, specific biogenous products (among biogenous products, main raw material is from human blood or tissue), oral medicine, intravenous, and external medicines. Packaging schemes are categorized into three kinds: dosage

packaging unit, sell packaging unit and bale packaging unit. The notice also requires manufacturers to provide serial number manufacturing codes, quantity, and expiration date on the barcode.

The JAN (Japanese Article Numbering) (The Distribution Systems Research Institute 2012) code is the product identification code of the Japanese Industrial Standards; it is designed to be compatible with EAN (European Article Number) of GS1. GS1 (Global Standard One) is a global organization dedicated to the design and implementation of global standards of supply and demand chain. The number of the packaging type and the JAN code together make up the product code of the ethical drug. The information level on a dosage packaging unit is necessary to ensure the proper medical treatment at the end point of accountability. "GS1 RSS (Reduced Space Symbology, recently renamed as "DataBar".) limited composition symbol CC-A" and "RSS-14 stack composition symbol CC-A" should be used.

As of 2010, the product code of the sale packaging unit is displayed on more than 99 % of medical supplies. However, as for the manufacturing number or the manufacturing code, only a specific biogenous product is 100 % (Ministry of Health Labour and Welfare Health Policy Bureau Economic Affairs Division 2012). The degree of labeling on other medical supplies is still low; the environment for traceability in the medical field is still developing. Neither barcodes nor RFID (Radio Frequency Identification) are completely adequate for labeling purposes at the moment; it is necessary to build a system that supports both barcodes and RFIDs.

6.2.2 Healthcare Management

The medical treatment system in Japan has traditionally used fee-for-service payments, but recently the payment method has been shifting to the prospective payment system. MHLW introduced the DPC (Diagnosis Procedure Combination) (Okamura et al. 2005) in 2003. While the DRG/PPS system is a "per-case payment" system, the DPC is "per-day payment"; it is generally believed that there is an incentive in shortening the average length of stay (LOS) to reduce medical expenses. When part of the medical treatment is fixed, controlling medical costs becomes the most important task for healthcare.

It is common that the business analysis in hospitals distributes and assesses the cost of ethical drugs based on the billing information of each patient and on a departmental basis. The practitioners enter the orders, and these orders are transferred to the medical business department to gather the claim information and generate the medical care claims bills.

The billing transaction process in Japan was computerized in 1999. However, the current ordering system merely records the history of ordering and dispensing medications, allows administrative checking, and converts the transaction information to billing claims. The billing rules are so complex that the medical treatments and the billings do not have a one-to-one relation. The billing does not reflect the

actual consumption of ethical drugs for medical administration purposes. Thus, it is impossible to determine the accurate picture of healthcare expenditure strictly from the billings.

Adopting the unit control of medical supplies and recording the exact medical treatment and procedures will allow for real cost accounting. However, checking the unit controlled medical supplies by scanning barcodes may increase the burdens on healthcare practitioners. Personnel costs comprise nearly half of medical expenditures (Ministry of Health Labour and Welfare Health Policy Bureau Economic Affairs Division 2009); thus, increasing the burdens on practitioners will put pressure on management to refine business analyses and practices. A medication checking system must require the least amount of personnel labor possible.

6.2.3 Operating Issues with Regard to the Ordering System

Healthcare services around a Japanese medical ward are limited due to poor housing conditions (Ministry of Health Labour and Welfare 1995). The lack of resources makes it difficult to build a cost effective and timely delivery system of maintaining a stock of ethical drugs at the ward and distributing them efficiently. Common practice is to have the pharmaceutical department arrange the delivery date for the drug order and deliver the drugs at the appointed time. The ordering system is recognized as a tool for reserving or backordering drugs over a long period (Tomohiro 2005). The real computer-based injection designation system has recently emerged.

Tanaka et al. reported that among all intravenous infusions at the hospital in 2007, less than 1 % of treatments were not authenticated, due to an emergency order by a physician (Kaihara et al. 2009). Among authenticated orders, 55 % were changed or canceled. This study shows that even when put on alert, nurses have tendency to repeatedly enforced some orders to be authenticated. The fact that 4 % of the override actions were the cause of malpractice incidents indicates that the healthcare workers are too close to medical accidents. Medical treatment cannot always be scheduled. A failsafe design in the checking system at a ward is very important. In addition, the long time span between dispensing drugs and administering treatment can also cause frequent order changes and cancellations.

Lacking a supply system that supports sustainable and prompt delivery for urgently required ethical drugs, practitioners have a tendency to order extra drugs so as to have them on hand. To change the focus from ordering resources to indications for medical treatment, the system should shorten the time between dispensing a drug and administering it. Collecting the log of authentication, the list of medicated ethical drugs, and the log of treatment time will enable realtime stock forecasting and better stock control.

6.2.4 Securing Medical Safety

To ensure medical safety, BCMA helps practitioners to ensure the five "rights" of medication administration (Koppel et al. 2008): "right patient," "right drug," "right dose," "right route," and "right time." On the other hand, there is a report pointing out that the effect of BCMA is limited and may even be one of the causes of medical accidents (Koppel et al. 2008). The controversy over the usefulness of BCMA stems from a lack of standardized definitions relating to the information and the workflow that BCMA should handle (Akiyama and Atsushi 2009; Henneman et al. 2007). In that sense, BCMA is not a mature system. There have also been few discussions about the absolute merit of the five "rights" (Shane 2009); the information for analysis and authentication is still not fully elucidated.

Akiyama et al. suggested that authentication of the "right drug" not only implies authentication of the right kind of drug, which is exactly what the physician has prescribed, but also implies checking whether a drug to be co-infused is co-infused correctly, as well as accessing a drug adverse reaction database to ensure that these drugs have no side effects related the medical administration (Akiyama et al. 2008a). After drugs are co-infused, there is a decrease in drug efficacy and bacterial growth as time goes on; mixing drugs more than 1 h from the prescribed time is inappropriate (Schneider et al. 1998). "Right route" is commonly focused on confirming the intravenous injection route. Additionally, improper treatments that deviate from the scheduled time should be suppressed. Checking whether additional treatments are medically appropriate is also required; this is conducted by calculating the daily dose (Akiyama and Atsushi 2009). In other words, securing medical safety does not involve merely authenticating items and times; it also requires that treatments are performed appropriately, using the right medications, at the prescribed time and place, and properly conducted using the correct workflow. To that end, we have to develop a system that accesses an adverse event database and queries the clinical decision support system instantly, via an authentication process, to judge whether the request is correct according to the "five rights".

6.2.5 Information Security

In healthcare, the sharing of patient information between practitioners, as well as immediate access to the information, should be guaranteed. Without this guarantee, patients' lives may be endangered. Efficient medical treatment may be hampered if access control with regard to medical records is inappropriate. The healthcare domain should establish an original security policy that balances the protection of information, considering fundamental patients' rights, and the disclosure of patient information to practitioners to ensure medical safety (Tsukuma et al. 2001).

Some paper suggested that instead of managing access control strictly, we should add audit functions to the medical information system. We may enhance

accountability by tracking personnel access and preventing fraudulent activity. In other words, guaranteeing immediate access to patient information, determining who accesses it, and recording these logs in a tamper-proof format are more important than preventing illegal access to patient information in healthcare.

6.2.6 Ethical Drugs and Traceability

Traceability in the healthcare domain is the ability to track ethical drugs from production to patient use. To that end, product information should accompany medical supplies from production to distribution. However, barcode re-labeling may be performed during physical distribution, hence it may not be possible to locate critical information, such as the lot number, and a medical center may also get the wrong ethical drugs if the re-labeling process itself is done in error.

One problem in this regard is that the information management units are different between the production, physical distribution and dosage stages. To bridge the gap between information management units, barcode re-labeling is undertaken. The production phase and the dosage phases require "Unit Dose", but in the physical distribution phase, labeling is done according to various packaging forms, such as palette, lot, the cardboard box, etc. Every time drugs are packaged and unpackaged, re-labeling may be required.

GS1 (Association of the old international EAN) has standardized the physical distribution process to resolve these issues. In the GS1 standard, GS1-128 (UCC/EAN-128), RSS (Reduced Space Composite Symbology) and RFID are used as Data Carriers. GTIN (Global Trade Item Number) and SSCC (Serial Shipping Container Code) are approved as the standard data format. GTIN focuses on consumption while SSCC focuses on physical distribution; GTIN and SSCC are mutually interchangeable. In the healthcare domain, most pharmaceutical companies use the EPC Global code, and it has become the de facto standard. The EPC uses SGTIN (Serialized GTIN) that has interchangeability with GTIN. In Japan, JAN (Japanese Article Number) is specified based on EAN and also has interchangeability with GTIN.

Japan has mandated that all ethical drugs are to be labeled with barcodes after 2008. Unit item management can identify the kind (name) of ethical drugs, but cannot identify individual ampoule bottles. Single item management can use the serial number to distinguish individual products, and it is indispensable for ensuring medical safety. Accidents in which practitioners mistake the mixed injection drug for another because the bottles appear the same will be avoided by distinguishing the individual bottles (Kondoh et al. 2008).

Therefore, SGTIN enables single item management and is regarded as an important component in the medical field. However, as the barcode is not currently displayed on all medical supplies, complete source marking is not now available. Every medical institution has to apply private "in-house" markings in each medical institution, which creates additional administrative burdens.

6.3 Issues Relating to BCMA

Nurses in a ward carry out most of the orders for patients during a hospitalization. Blood transfusions are primarily reported by the nurses at a ward, implying that many invasive and high-risk medical treatments are conducted at the ward; dependable authentication should be performed beforehand. Below is a typical workflow process from ordering the blood transfusion to the actual transfusion to give a general idea of the workflow at a healthcare setting:

A physician inputs the blood transfusion order via CPOE (Computer-based Provider Order Entry). The blood type of the patient is registered on an electronic medical record, previously inspected by a blood transfusion department system. The blood transfusion department accepts the order from the physician and performs the radiation on the blood bag and dispenses it. At the staff station, nurses verify the dispensed blood with the form issued by CPOE; then, they carry the blood to the patient's bedside. The nurse scans the barcode on the staff identification plate and inputs it as the performer's identity. Then she scans the barcode on the hospital card of the patient. Finally, she scans the barcode on the blood bag to perform three points authentication (Dzik 2007).

Because the authentication process requires the authenticating person and materials at the ward, mobile terminals such as a PDA (Personal Digital Assistant) and PHS (Personal Handy-phone System), attached to a barcode reader, are widely used. In Japan, BCMA has been implemented on mobile terminals since the 2000s and has spread rapidly (Akiyama 2007a). The number of negative incidents has been remarkably reduced in hospitals using BCMA (Watanabe et al. 2006; Matsuda et al. 2006; Makoto 2004); however, such incidents have not been completely eliminated.

The patients wear a wristband with a barcode in many hospitals, but the responses from patients in this regard have not been positive (Yano et al. 2008). Therefore, some hospitals use a hospital card instead of the wristband, using the wristband only in a limited number of situations, such as during operations.

However, these sorts of measures may be the cause of certain problems. Too many barcodes required for authentication (Tomohiro 2005), and the complicated operation of the mobile terminal, can lead to nurses bypassing authentication (Watanabe et al. 2006) or refraining from using BCMA; there are many reports that nurses have been hesitant in using BCMA (Yano et al. 2008; Tateishi et al. 2008). For example, the light of a scanner is very bright, which can disturb sleeping patients. Another example sets out how a nurse gave up using the terminals because the terminals were not charged and spare terminals could not be found immediately.

A system that reduces the burden on practitioners is, obviously, desirable (Lisby et al. 2005; Kaplan 2005). Koppel analyzed the 'workarounds' of BCMA and their causes in detail (Koppel et al. 2008): (1) The user administers medication without scanning the medication barcode to confirm whether it is the correct medication, leading to wrong medication administered, (2) the user administers medication without scanning patient ID barcode to confirm it is the correct patient, leading to

the wrong patient receiving medication, and (3) the user does not check or verify the patient's new medication orders before administering medication, leading to wrong medication dosage or administration route. The most prominent probable causes are: (1) The scanning procedure is slower or more difficult than other methods because it may conflict with workflow efficiency (Watanabe et al. 2006; Tateishi et al. 2008), (2) Users are not well trained in using the adequate procedures, and (3) Users are not aware of hospital medication use policies, e.g., double checking for high-risk medications. In other words, from the viewpoint of BCMA, practitioners act inappropriately; from the standpoint of human design, current BCMA may be one of the worst products in the medical field, due to a lack of sensitivity about human nature built into its design.

The PDA introduced from 2000 to 2007 cannot be said to be comfortable for the nurse because its performance (Watanabe et al. 2006), size and weight are far behind the ideal form (Yano et al. 2008). Windows CE-based terminals were mainstream in those days, and these terminals had to expand to contain the high-capacity battery and scanner modules needed to support longtime operation in the ward. As a result, the size and weight of the terminal were increased to the point where it was difficult to call it "mobile". This became a major reason why nurses did not want to effectively use BCMA. Other reasons to avoid BCMA include the fact that the barcode is sometimes hard to scan, depending on the surface shape (Yano et al. 2008; Tateishi et al. 2008); additionally, the pattern of the barcode may be distorted, broken, or stretched.

Currently, most healthcare settings do not use the barcode labeled at the time the product is shipped from the manufacturer, but use a barcode that the SPD (Supply Processing Distribution) center or pharmaceutical department provides when it is delivered to the healthcare setting. When drugs require refrigeration, the labels may freeze and come off or condensation may blur the information (Yano et al. 2008). When the labels have to be re-labeled, there may be a chance that the wrong label is applied. Some healthcare facilities re-label drugs after mixing an injection at a ward. There may be also a possibility of mislabeling when the practitioner mixes drugs for multiple patients at the same time.

6.3.1 RFID Overcomes the Problems of Barcode

It has been repeatedly pointed out that barcode authentication, relying on optical technology, has usability problems: (1) A scanner's orientation and focus need to be precisely oriented to the barcode, which requires great care, (2) Scratches, dirt, or leaking fluids, such as blood, can make the barcode unreadable, (3) The barcodes on a soft and deformable surface such as a wristband or intravenous feeding bags are sometimes unreadable, (4) Attaching barcodes to a patient's body may disturb the patient's sleep and rest. It may also upset patients because it detracts from their individuality, (5) It requires scanning multiple barcodes to mix multiple injections, (6) With traditional distribution processes, multiple barcode standards coexist and

sometimes re-labeling is required (Kondoh 2007). These defects place a burden on practitioners.

In comparison to optical barcode technology, the RFID (Radio Frequency Identification) utilizes the characteristics of radio, which has the following advantages: (1) The direction of an RFID reader does not have to exactly match the IC tag, and it is readable even if there is shielding (noncontact authentication), (2) RFIDs can read more information and more precisely than a barcode. Some IC tags can also be written to or have write-once capability, (3) Multiple IC tags can be read at the same time, (4) There is enough room in RFID for reading information so automation of scanning materials is possible. In other words, the problems of barcodes will be resolved by utilizing RFID's characteristics.

6.3.2 RFID Trials in Healthcare

Kondo et al. developed a medical PDA with RFID reader and a wristband that has an IC tag built-in (Kondoh 2007). They conducted a feasibility study at a medical ward in 2004. Before medical treatment, the practitioners perform user authentication by scanning the IC tag in a staff identification card. Then, they scan the tag on the medication and the patient's wristband to confirm that the drug matches the order of the physician. As a result, injection related incidents decreased, and they can expand the coverage to both blood transfusions and outpatient chemotherapy. There is the case replacing the conventional barcode with IC tags. This study showed that an IC tag has a higher input efficiency and more efficient treatment than the cases with barcodes (Kondoh 2007; Ota et al. 2008).

One in 10,000 people are reported to have surgical instruments or gauze left inside the body after an operation (Gawande et al. 2003). The number of surgical instruments used in one operation can be several hundred, depending on the operation. The nurse in an operating room has to count all instruments and to confirm that no items are missing before, during, and after the surgery. The surgical instruments are stored in a container and sterilized after irrigation. The distribution of instruments to each container is also performed by manual labor, and approximately 2 % of distribution work may include the wrong items (Yamashita et al. 2009).

The MHLW (Ministry of Health, Labour and Welfare) mandates, via the Amendment of Pharmaceutical Affairs Law of 2007, the safe management of surgical instruments and setting the expiration date of instrument based on usage count (Ministry of Health Labour and Welfare Pharmaceutical and Food Safety Bureau Safety Division 2003). This mandate aims to establish more effective medical safety practices by changing maintenance management from a non-binding guideline to a requirement (Akiyama 2007b). However, a medical institution with many surgeries often has 4,000–7,000 operations every year and manages more than 100,000 instruments (Yamashita et al. 2009). At present, no healthcare facility has managed surgical instruments on a unit management basis. There is no evidence available for surgery frequency and the failure rate of instrument counting.

MHLW's demands for safety management will result in a huge burden on healthcare unless countermeasures are taken.

The use of IC tags with surgical instruments is expected because of the IC tag's capability of providing multiple item authentications at the same time. Marcario had tried to find the gauze left in a human body by scanning a small IC tag attached into the gauze (Macario et al. 2006). However, we have to overcome a weak point of the IC tag in order to account for surgical instrument materials. Surgical instruments are mainly made of metal, and sterilization is necessary. Ethylene oxide gas sterilization is used for precision instruments, such as an endoscope, that should not be heated at high temperatures. Steel devices, such as scalpels or forceps, are sterilized by high-pressure steam (Wolfgang et al. 2009). IC tags need to be resistant to high temperatures and chemical agents. IC tags should also have impact resistance because they can be subjected to the impact of automated cleaning and transportation. IC tags are required to maintain readability under these severe environments.

To address these issues, Yamashita et al. developed the ceramic IC tag, which buried a small IC tag in a ceramic body; this allows the tag to perform durability management by logging usage frequency and the history of surgical instruments through the cycle of irrigation, sterilization, and keeping (Yamashita et al. 2007). The ceramic IC tag is resistant to high temperature, pressures, and chemical agents. The advent of the ceramic IC tag eliminates the areas where IC tags cannot be used in healthcare, and may lead to ubiquitous use. The issues that remain to be solved are reducing the costs, standardization of the information on IC tags, and development of a tag management system.

6.4 Challenges for the Future

6.4.1 Workarounds for Barcode

There are some problems with regard to BCMA that need to be resolved. One is that the mobile terminals of BCMA have a tendency to be heavy, because a barcode scanner module has to be attached to the terminal. The labels on a deformable package or on a curved surface are difficult to read. Machine error, unreadable barcodes, and users forgetting to read the barcodes are major risk factors that threaten medical safety (Koppel et al. 2008). However, barcode systems cost less than RFIDs, hence it is expected that barcodes will coexist with RFID in the future.

One future challenge is that of developing a mobile terminal that can process barcodes more easily. One possible solution is a smartphone equipped with an AF (Auto Focus) camera. Smartphones have high-speed processors so they can handle more advanced image processing than conventional PDAs, in a shorter amount of time. Reading barcodes with AF cameras and performing advanced image

processing may increase the recognition rate of barcodes. As robust barcode recognition algorithms are researched (Gallo and Manduchi 2009; Wachenfeld et al. 2008), it is expected that more efficient BCMA may be developed.

6.4.2 Expand the Use of RFID in Healthcare

Investigation of the effects of electromagnetic waves from RFID devices in healthcare settings has not been adequately performed (Akiyama et al. 2006). There have been studies of the effect of radio waves produced from RFID devices on medical equipment in laboratory settings (Ministry of Internal Affairs and Communications 2006), but little research has been conducted in real medical facilities.

There are huge amounts of transaction data that contain patient status, medication history, and the list of administered drugs with a lot-number. A distributed processing technology to handle such data efficiently is required to realize realtime CDSS (Clinical Decision Support System). To effectively work with the life cycle management of ethical drugs' supply, safekeeping, mixture, administration and disposal, the standardization of a drug master code and a medical information model should be developed. Solving these issues will accelerate the expansion of RFID in healthcare.

6.4.3 Data Mining for Medical Safety

Akiyama et al. developed POAS (Point of Act System), a system that collects the transaction logs of medication administered to patients. By conducting data mining on tens of millions of transaction data, they found that warnings about an injection occurred most frequently when the nurses' shift change occurred (Akiyama et al. 2008b). Data mining based on the real dynamics of medical treatment is impossible with conventional ordering systems and medical electronic records. By using mobile terminals, the practitioner, patient, medications, injections, place, time, and routes are all recorded, allowing investigation into which part of the workflow medical accidents most frequently occur. Analyzing the time lag and the route between ordering and administering medication may optimize stock and material distribution.

This kind of data mining has already been performed in other fields, but data mining in healthcare is still in the early phases of development. As I have described previously, the standardization of the medical information model is still developing, and we have to combine complicated, structured data to build data mining targets because the treatment process includes many kinds of administering medication, and these administration transactions are stored separately.

6.4.4 *Introduction of Smartphone to Healthcare*

The introduction of information technology to the healthcare field has demonstrated that such technology can reduce medication errors; however, there is no evidential support for increased adherence to protocol-based care (Wu et al. 2006), and many studies lack a financial analysis of the introduction of mobile terminals in preventing medical accident; the real cost effectiveness is still unclear. However, making the shift to smartphones from PDAs or special-purpose barcode readers will improve the cost-effectiveness aspect.

PHS (Personal Handy-phone System) is very common in Japanese healthcare settings; the GSM (Global System for Mobile) and CDMA (Code Division Multiple Access) based cellular phones are not used. The evidence of the influence on medical equipment of cellular phone's radio waves has been unclear until recently, so hospital managers have hesitated to introduce GSM or CDMA cellular phones. The smartphone's capability to connect to multiple channels such as Wi-Fi, 3G and 4G wireless technology is an advantage, but its advantage also may be a weakness because more channels means it is more open to security risks.

Through the smartphone, enormous amounts of personal information will be exchanged. We have to develop distributed processing systems that can service the realtime clinical decision support while providing adequate security (Ministry of Health Labour and Welfare 2010). It will be necessary to develop the authentication system closely with cloud computing technology. There are many issues that hospital managers should take into consideration before introducing smartphones into medical institutions.

6.5 Conclusion

Research into ensuring medical safety and analyzing the medical business process with mobile terminals has been conducted for more than 10 years. The course of this research has not been smooth, and there are many remaining problems. However, I expect that the advent of smartphone implementation will provide a break-through for several reasons: The major problems of BCMA are the low-quality design of user interface and the performance issue on barcode reading. Smartphone processor performance is now surpassing former high-end workstations while the more sophisticated interface and more robust barcode recognition by high-performance image processing will make BCMA more useful.

Furthermore, a smartphone equipped with NFC (Near Field Communication) will be expected to integrate barcode and RFID into one item. This capability will be available in many commercial products so that all healthcare members may change from PHS to smartphones, and they will be ready to conduct medical administration authentication no matter what the time or location. In addition, smartphones support many channels such as Wi-Fi, 3G and 4G wireless

technologies at the same time. The practitioners can conduct medical administration anywhere.

The smartphone seems promising, but there is little empirical evidence of its effectiveness in the healthcare domain. We have to verify the smartphone's usability in the future.

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