An innovative mobile approach for patient safety services: The case of a Taiwan health care provider

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Abstract

As the importance of patient safety increases for hospital management, many health care providers have begun to use innovative mobile technology to make their procedures more accurate and efficient, and to reduce the risk of human error. This paper explores an innovative mobile approach for patient safety and health care services in a Taiwan hospital, where a web-based patient safety services (PSS) system was implemented to enhance the efficiency of diagnosis and patient safety. The functions and operating procedures of the PSS system are introduced. Furthermore, the contributions of the PSS system over a six-month period of clinical use are analyzed. Finally, the managerial implications of mobile PSS are discussed.

Keywords: Patient safety; Mobile health care service; Health care providers; Mobile technology

1. Introduction

The Institute of Medicine (IOM) report, "To Err Is Human: Building a Safer Health System," thrust the issue of medical errors into the spotlight and garnered unprecedented attention (Kohn et al., 2000). As medical errors have become a significant cause of morbidity and mortality among patients (Boxwala et al., 2004), the issue of patient safety has become increasingly important (Newbold et al., 2004). Also, meeting customer demands for various quality services is a key to retaining a competitive advantage (Ma et al., 2002). Therefore, patient safety has become an important component in an increasing number of health care quality assurance programs (Pedreira and Marin, 2004).

The innovative development and application of information technology (IT) plays an important role in patient safety and health care by enhancing quality of services. The word, "innovation" is often used to describe changes in the products or services a firm offers and the ways in which it creates and delivers those offerings (i.e. process innovation) (Francis and Bessant, 2005). Regarding the innovation of health care services and delivery processes for patients, IOM (2001) issued, "Crossing the Quality Chasm: A New Health System for the 21st Century," which focused on adopting IT in order to achieve a 21st Century health care system that is evidence-based, patient-centered, and systems oriented. Therefore, Ball et al. (2003) consider IT instrumental to innovation in hospitals.

Because patient safety is an important issue for hospital management, a variety of approaches have been implemented to identify medical errors and their causes (Boxwala et al., 2004). With an innovative IT approach, health care providers can improve their services and their delivery processes with an eye toward improving patient safety. Certainly, IT has the potential to transform the

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delivery of care by streamlining processes, making procedures more accurate and efficient, and reducing the risk of human error (Ball et al., 2003). However, considering the current state of health care practice, it is evident that the new telemedicine and IT solutions have yet to be implemented and integrated into the health care delivery scene (Maglaveras et al., 2002).

In recent years, biotechnology in health care has been emphasized (Canongia et al., 2004), and a number of handheld mobile communication devices have gained prominence and have had a significant impact on global business operations (Kumar and Zahn, 2003). Meanwhile, mobile technology has seen an explosive growth and now enables largely telematic applications in all facets of life including health care (Maglaveras et al., 2002). Consequentially, the use of information and communication technology to facilitate health and social care delivery to individuals in their own homes has been proposed (Barlow et al., 2006). Mobile health care computing devices are rapidly becoming an integral part of health care information systems (Lin and Vassar, 2004). Using mobile information and communication systems in the clinical routine has the potential to greatly improve communication, facilitate information access, eliminate double documentation, and increase the quality of patient care in the long run (Ammenwerth et al., 2000). Doubtless, wide adoption of mobile computing technology has the potential to improve information delivery and so aid effective decision making in health care (Lu et al., 2005), and, in doing so, to improve patient safety. However, patient safety programs largely address provider interests and many times overlook patient preferences and needs. Consequently, current initiatives in patient safety focus on devices, procedures, professionals, and health care delivery systems (Brennan and Safran, 2004).

As the delivery of health care becomes increasingly complex, the reliance on effective systems to prevent medical errors will become increasingly critical (Ortiz et al., 2002). However, while it can support patient safety by correcting problems inherent in older technology, IT can also bring new sources of error (Goldstein et al., 2002). Therefore, the widespread adoption of information and communication technologies characterizing the recent competitive scenario has been of great interest to researchers and practitioners (Carbonara, 2005).

2. Study aims

In clinical practice, the misplacement of test results is common, compromising patient safety. Testing centers systematically notifying both patients and providers of important test results by e-mail is contributive to patient safety (Sung et al., 2006). Longo et al. (2005) pointed out that in Missouri and Utah (in 2002 and 2004, respectively) while 74% of sampled hospitals reported full implementation of a written patient safety plan, nearly 9% reported having no plan at all. In Taiwan, the use of mobile technology to deliver patients' abnormal test results to medical staff and patients is an innovation in medical care. Consequently, designing a prototype and exploring the impact of a patient safety services (PSS) system is essential to reducing new error sources and improving patient safety.

This study describes a PSS system consisting of a mobile health care service (MHS) subsystem and a high risk reminder and surveillance (HRRS) subsystem, and analyzes its impact on patient safety over a six-month period of clinical use. The paper is organized as follows. First, the deficiencies in health care provision in practice are depicted. Next, the service functions of the PSS system are discussed. Then, in studying the development of the PSS system for the purpose of patient safety service, this study highlights those aspects of the system that contributed to an improvement in hospital services and patient safety. The final section summarizes the case illustration and discusses implications for health care providers.

3. Deficiencies in health care provision in practice

The activities of health care providers depend greatly on information and communication. Physicians, department administrators and secretaries all endeavor to provide the highest quality of service to patients, but important reports are occasionally not delivered smoothly and on time. Even outpatients are sometimes at risk, as they might forget their appointments, check-ups and so on. A clearer picture of the major impediments to providing quality hospital care and medical services can be gained from the following illustrations.

3.1. Deficiencies in provider–patient communication

With regard to patient need, there are some deficiencies as follows. Patients often wait a long time at the doctor's office before receiving treatment. Some patients are too busy to remember their medical appointments. Notifications of preventive medicine physical check-ups are not delivered promptly. Patients spend a long time waiting at inpatient ward counters to be admitted. Health care providers are unable to notify large numbers of patients for lectures, birthday greetings and health care reminders. Looking forward to getting better service, most patients expect their hospital or health care provider to provide better patient services by notifying patients individually.

3.2. Deficiencies in intra-provider communication

With regard to the needs of hospital physicians, administrators and secretaries, there are some deficiencies as follows. (1) Physicians: laboratory, radiology, and pathology reports may have difficulty reaching the patient or attending physician immediately after detection of critical results. In the case of emergent events such as adverse drug reactions, patient falls, or extubation, it is

difficult to notify physicians and nursing supervisors immediately. (2) Administrators and secretaries: rapid notification of additional physicians to report to the emergency room during a large influx of emergency room patients is difficult. In addition to high-risk patient notifications, critical reports sent to administrators and secretaries concerning financial reimbursement and revenue, outpatient visits, inpatient occupancy rates and emergency room daily patient numbers, are often delayed. These numerous administrative reports need to be received promptly.

3.3. Expected improvements to patient safety services

Both provider–patient communication and intra-provider communication need to be improved. If health care providers adopt mobile technology to improve those deficiencies, patient safety service quality can be effectively increased. This study proposes mobile patient safety services designed to solve information delivery difficulties for patients, physicians and administrative staff. For instance, by delivering appointment notices to dedicated patients, mobile services could help patients avoid wasting valuable time waiting in line for treatment. Moreover, the services might contribute to a reduction in the no-show rate and improve operational efficiency of the health care provider. Also, patient safety reminders can be delivered to patients, and medical staff can be informed of patients at high risk. Delivering customized services to targeted patients may improve the relationship between health care providers and their patients.

Due to limited resources, many miscellaneous patient services currently cannot be offered. Thankfully, mobile patient safety services can improve operational efficiency for health providers and provide better health care and related services for patients.

4. Case study: the patient safety services of a Taiwan health care provider

4.1. Background

According to reports by the International Telecommunication Union (ITU), the per-capita use of cellular telephones in Taiwan was number one worldwide in 2001 and 2002. In the third quarter of 2003, cell phone use reached its highest peak at 113% (MTC, 2005). Although cellular telephone use fell after 2003, in the second quarter of 2004 year it was still 101.81%. This implies that, in Taiwan, the cellular telephone has been assimilated into daily life. However, there are few hospitals providing mobile services for patients or for use by professional staff in intra-hospital communication. Most health care providers in Taiwan are still using traditional methods (i.e. written documents or telephones) to deliver critical information. To improve efficiency, the Municipal Wan-Fang (W.F.) Hospital introduced advanced mobile services to insure patient safety and improve the quality of their health care services.

4.2. Case description

In 2004, a PSS system was designed and first implemented by The Center of Patient Safety Informatics (PSI) of W.F. Hospital, a Taipei, Taiwan teaching medical center affiliated with Taipei Medical University. The project leaders consisted of physicians and hospital administrators who had daily contact with outpatients and were familiar with health care service delivery channels. All project members understood the needs of inpatients and outpatients. Members of the PSS project comprised 124 physicians specializing in Internal Medicine, Urology, Immunology, Cardiology, Infectious Diseases, Hematology, Psychiatry, Neurology, Comestic Surgery, Surgery, Dermatology, Gynecology, Pediatrics, ENT, Family Medicine and Oncology. Also included were two medical affairs administrators and one hospital superintendent.

The PSS systems was implemented in three stages. In the first stage, the project members individually suggested various services that might be improved by mobile technology, based on concerns for patient needs and efficient health care delivery. During the second stage, project members analyzed those service needs according to their experience in practice and designed the PSS system. In the final stage of implementation, the PSS system was employed over six months, after which the benefits of the system were analyzed.

4.3. The PSS system

After discovering and learning about issues related to patient safety, the W.F. Hospital team developed the PSS system to deliver mobile patient safety services, as below:

(1) MHS subsystem. This subsystem was designed to improve the quality of patient services by employing the cellular telephone system. As Table 1 shows, the various services provided by the MHS subsystem acted as helpful tools in improving health care services for both health care providers and patients by managing and distributing health care notifications.
(2) HRRS subsystem. This second subsystem was designed to deliver critical abnormal test results of severely ill patients from Laboratory, Radiology, and Pathology departments. As Table 1 and Fig. 1 shown, when HRRS discovered an out-patient's abnormal test result, the HRRS subsystem delivered important notifications to physicians within 5 min by cellular telephone short messages and Internet e-mail messages; meanwhile, MHS sent short messages to dedicated patients as well.

At present, there are many services that most health care providers cannot afford to offer since they would have to be handled by the medical staff; however, mobile patient

Table 1
The service items of MHS subsystem

PSS service items	Present patient service	Mobile patient safety service
Medical/examination notification service		
1. Patient appointment inquiry	Outpatients call physician's office	Outpatients → MHS
2. Pre-appointment patient reminder	Hospital staff send e-mails to or call patients, but only some service items are executed due to limited resources	MHS → Outpatients
3. Current treatment schedule notification		
4. Pre-physical check-up and precaution procedure notification		
5. Inpatient wards waiting notification		
6. Pre-surgical operation notification		
7. Medication safety notification		
8. Routine check-up notifications for pregnant women		
9. Hospital adult check-up service notification		
10. Pap smear notification		
11. Pediatric disease vaccine service notification		
12. Missed appointment notification		
13. Abnormal test result from check-up/return to hospital for treatment service notification	Hospital staff call patients and medical staff. The present way is inefficient	MHS → Outpatients HRRS → Physicians & nurses, Department directors & secretaries
Preventive medicine and relationship mgt. service		
14. Past due patient payment notification service	Only some service items are executed due to limited resources	MHS → Outpatients
15. Lectures notification		
16. Hospital community activities notification		
17. Physician and patient relationship management		
18.Birthday greeting notification		

safety services of the PSS system are executed automatically by computer rather than by hand-carried paper copy. In other words, mobile technology expands the scope of patient services and improves the quality of patient safety services.

4.3.1. The MHS subsystem

All service items of the MHS subsystem are listed in Table 1. Five items are classified as preventive medicine and relationship management services; the other items are classified as medical and examination notification services. Among all service items, only the "patient appointment inquiry service" responded to patient inquiry; the other services were executed by the MHS subsystem automatically. The four categories of MHS service functions were delineated as (see Fig. 2):

(1) Appointment inquiry notices. The MHS subsystem provided an automated inquiry function for patients. When patients checked their current status at the outpatient clinic (where they were in the waiting room "line"), the MHS subsystem responded with a message on their cellular telephone screen. Taking into account the difficulty aging patients might encounter when reading a small cell phone message, the MHS subsystem also provided voice message services which gave them an oral report of their status.
(2) Patient appointment notices. There were three services provided. First, a "pre-appointment notice" notified patients one day prior and again 4 h prior to scheduled visits. Second, the "patient treatment number notice" automatically reported to patients their current place in the waiting line. Finally, a "missed appointment notice" sent a reminder to those patients who failed to make their scheduled clinic appointment. These notices contributed to a reduction in the no-show rate for outpatients and hence a savings in operational costs.
(3) Patient safety reminders. The MHS subsystem provided safety warnings, reminders, and notices to contact the physician or pharmacist when patients were prescribed medicines with potentially negative side effects.
(4) Patient relations management. The MHS subsystem delivered messages to targeted patients for wellness and health management services as well. The notices were designed to maintain a good relationship between patients and physicians.

4.3.2. The HRRS subsystem

As described in the following section, the HRRS subsystem was delineated with reference to its workflow stages.

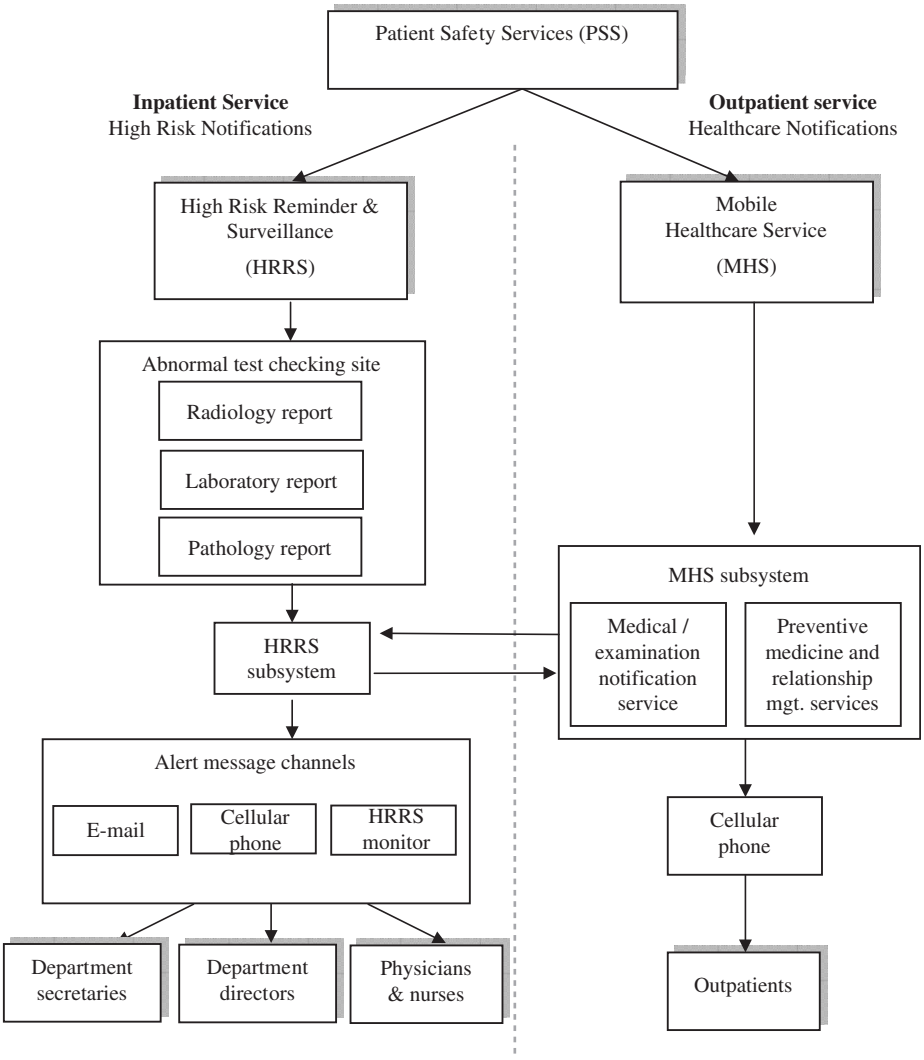


Fig. 1. The architecture of the PSS system.

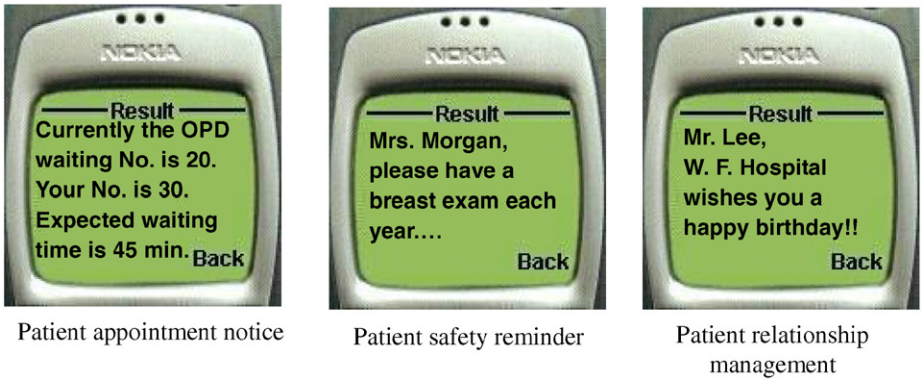


Fig. 2. Sample messages sent from the MHS subsystem.

(1) Stage one: recording patients' test results. After the patient had completed a test in the Laboratory, Radiology or Pathology department, the laboratory technician, radiologist or pathologist entered the test results into the HRRS subsystem by manually keying in the information or by using an automated computer system.
(2) Stage two: checking the test results. Employing standard indicators of severely abnormal test results of ancillary, radiology and pathology exams, the

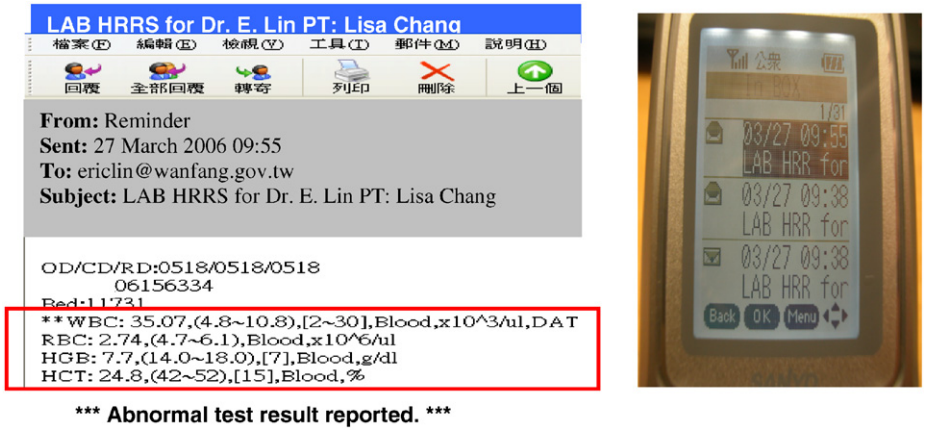


Fig. 3. Sample HRRS subsystem alert message sent via e-mail and cellular phone.

patients' test results were evaluated. When test results fell within critical abnormal ranges, the HRRS subsystem sent alert messages within 5 min.

(3) Stage three: delivering alert messages. Three channels were used to deliver HRRS subsystem alert messages, as shown in Fig. 3: *Cellular phone short messages*, by which the HRRS subsystem delivered brief abstracts of patient test results; *Internet e-mail messages*, by which the HRRS subsystem delivered detailed test results; *Patient surveillance information*, by which Intensive Care Unit (ICU) physicians could monitor the condition of critically ill patients.

(4) Stage four: meeting medical care responsibilities. Primary care physicians, department directors, department secretaries and nurse stations were the recipients of information generated by the HRRS subsystem. *Physicians* received short cellular telephone and Internet e-mail messages, which were delivered after critical abnormal test results were reported; *Department directors* closely monitored critically ill patients via HRRS subsystem notifications; *Nurse stations* were assisted by the HRRS system in monitoring the condition of critically ill patients.

4.3.3. The interaction of the MHS and HRRS subsystems

As presented in Fig. 1, when test results were entered into the HRRS subsystem, the subsystem compared patient's test results to standard norms. Where the HRRS found a patient with abnormal test results, this subsystem sent alert messages by means of the alert message channels described above. Physicians and nurses, department administrators and secretaries all received alert messages instantaneously and simultaneously. The alert message sent from the HRRS subsystem was also sent to the MHS subsystem. Sung et al. (2006) pointed out that patients often become unnecessarily frightened when they receive abnormal test results. As described in Table 1, the MHS subsystem also sent patients safety notifications that were gently worded in order to diminish the patient's anxiety. Meanwhile, the MHS subsystem sent administrative information to the HRRS subsystem. The alert message channels of the HRRS subsystem were helpful to hospital administrators in managing the efficiency of the hospital's health care delivery systems.

5. Results

The major services based on the PSS system were divided between the MHS and HRRS subsystems. After the experiment period, the outcomes of PSS system use were assessed, as follows.

5.1. The outcomes of MHS subsystem use

Outpatients averaged around 4000 per day. Most patients were very impatient with waiting in line to register and then waiting a long time to see their doctor. This condition not only consumed patients' valuable time, but also reduced hospital revenue due to a high no-show rate. Table 2 indicates that there were 16,155 no-show patients from January 2004 to July 2004, a rate of 16% per month. For hospitals, each no-show patient means a loss of three kinds of fees, e.g. a registration fee (US $5 per patient), a patient record processing fee (US $0.7), and a diagnosis and pharmacy ancillary per patient fee (US $5.8). Without MHS services, no-show patient cost and revenue losses were around US $185,783 per month for W.F. Hospital.

During the period from August 1, 2004 to January 31, 2005, W.F. Hospital offered MHS services to patients. After implementing the MHS subsystem, W.F. Hospital analyzed the no-show rate, and the results indicated there were 13,125 no-shows, a monthly rate of 13%. Comparing with the period prior to the introduction of MHS service, monthly no-show patient cost and revenue losses were down to US $150,938. As Table 2 shows, W.F. Hospital decreased their losses by around US $34,845 each month. In other words, by implementing MHS services, W.F. Hospital could possibly increase their revenues by about US $418,000 per year.

Table 2
The outcomes of MHS subsystem use

System implementation stage	Average monthly no-show patients	No-show rate (%)	No-show patients' loss of registration fee US $5 per patient (a)	No-show patients' medical per record processing fee cost US $0.7 (b)	Loss of diagnosis, pharmacy ancillary per patient fee US $5.8 (c)	No-show patient cost and revenue loss monthly (a + b + c)
2004/01–2004/07 (before implementation) (s1)	16,155	16	$80,775	$11,309	$93,699	$185,783
2004/08–2005/01 (after system implemented) (s2)	13,125	13	$65,625	$9188	$76,125	$150,938
Contribution to monthly revenue and cost saving analysis (r1) ($r1 = s1 - s2$)	3030	3	$15,150	$2121	$17,574	$34,845
Forecast contribution to yearly revenue and cost saving analysis (r1*12 months)	36,360		$181,800	$25,452	$210,888	$418,140

To further contribute to revenues, these improved outpatient services could also be extended to preventive medicine. As the majority of hospital funds in Taiwan come from Bureau of National Health Insurance (BNHI) reimbursements, most hospital activities are limited by BNHI regulations. However, preventive health examinations are not so strictly controlled. In addition to providing a public health service, offering health examinations could contribute to finding potential patients. Finding new patients and increasing the quality of services provided to current patients is central to the new approach to customer relations management (CRM). Therefore, offering health examinations blends with the CRM concept to enhance the competitive advantage of health care providers. With the assistance of the MHS system, W.F. Hospital managers were able to provide customized and innovative patient service to enhance patient satisfaction.

5.2. The outcomes of HRRS subsystem use

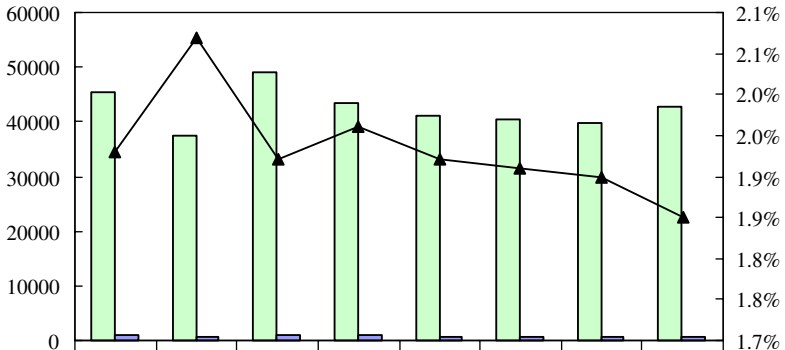
For inpatient services, the HRRS subsystem provided short cellular telephone and e-mail messages from Laboratory, Radiology, and Pathology departments, notifying physicians and medical staff about their critically ill patients. Reports of critical abnormal test results were analyzed as follows:

(1) High risk Laboratory Department reports. As Fig. 4 shows, reports of critical abnormal test results by the Laboratory Department from January 1, 2005 to August 31, 2005 were analyzed. The Laboratory Department sent approximately 800 abnormal test messages to the medical staff monthly. Over these eight months, the highest percentage of abnormal test results was seen in the Emergency Room (24% of tests), while other departments saw lower percentages: Department of Obstetrics and Gynecology, 13%; Pulmonology 10%; Gastology, 10%; Renal, 9%; Hematology, 5%, General Surgery, 5%; Cardiology, 4%; others (Cardiac Surgery, Endocrinology, Department of Internal Medicine, Infection Disease, Neurology, Neuro-Surgery) were around 2–3%. Over the eight-month period, there were 339,598 laboratory tests conducted, and of those tests, the results of 6561 (approximately 2%) fell within abnormal ranges.

(2) High risk Pathology Department reports. As Fig. 5 shows, reports of critical abnormal test results from the Pathology Department from January 1, 2005 to August 31, 2005 were examined. The Pathology Department sent approximately 41 abnormal test message to the medical staff monthly. Over these eight months, the higher percentage of abnormal test results was seen in General Surgery, 27%; Gastology, 25%; and Urology, 12%. Other departments saw lower percentages: Gynecology, 8%; Pulmonology, 5%, Neuro-Surgery 5%, ENT, 4%; others (Orthopedics, Dermatology, Dental, Other Surgery, Internal Medicine departments) were around 2–3%. Over the eight-month period, there were 329 abnormal test reports (approximately 4%) among the 8367 pathology tests conducted.

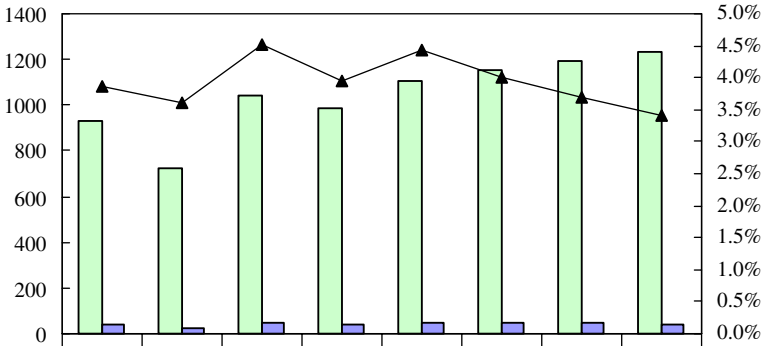
(3) High risk Radiology Department reports. Reports of critical abnormal test results from the Radiology Department from January 1, 2005 to August 31, 2005 were also examined. Fig. 6 shows that the Radiology Department sent an average of approximately 23 abnormal test messages to the medical staff each month during the experimental period.

With the HRRS, the risk to patient safety was detected early, and the patients concerned were notified to see their primary physician for further information and care. By replacing the paper notification system with the HRRS system using mobile short message and Internet mail to physicians from Lab, Radiology, and Pathology



	2005/01	2005/02	2005/03	2005/04	2005/05	2005/06	2005/07	2005/08
Total tests	45475	37579	48902	43465	41054	40535	39858	42730
High risk tests	877	778	941	850	789	776	759	791
Rate	1.93%	2.07%	1.92%	1.96%	1.92%	1.91%	1.90%	1.85%

Fig. 4. High risk reports from the Laboratory Department (2005/01–2005/08).



	2005/01	2005/02	2005/03	2005/04	2005/05	2005/06	2005/07	2005/08
Total tests	934	721	1041	987	1104	1150	1194	1236
High risk tests	36	26	47	39	49	46	44	42
Rate	3.85%	3.61%	4.51%	3.95%	4.44%	4.00%	3.69%	3.40%

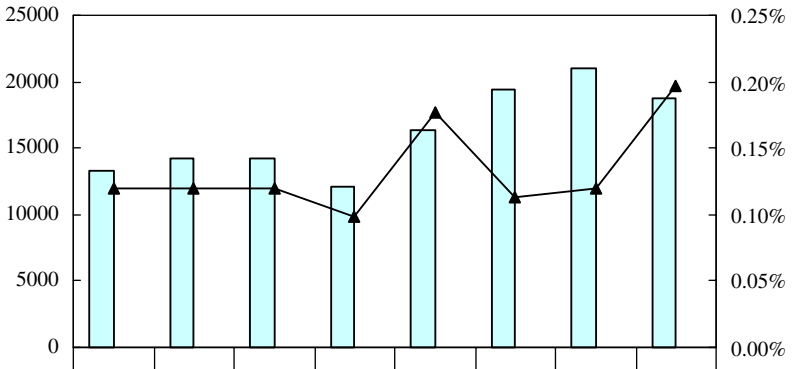
Fig. 5. High risk reports from the Pathology Department (2005/01–2005/08).

departments, the time required to deliver abnormal test results was decreased from 37 to 29 h for inpatient notifications and from 30 to 11 h for Emergency department notifications. The HRRS clearly contributed to significant improvements in communication, preventing errors and increasing safety.

In practice, a majority of physicians felt that the PSS system helped them to improve the quality of care and patient service. Not only did the HRRS cellular phone short message system deliver abstracted information to physicians, but also, when physicians wanted more detailed information about their high-risk patients, they were able to review the patients' files via the Internet. Therefore, using the PSS system to receive/retrieve patient information was helpful to physicians in making medical decisions and in increasing patient safety. The PSS system provided a better communication channel, reducing the proximal causes of medical errors and other adverse events in patient care.

6. Conclusions

Long-term success in the pharmaceutical and biotechnology industries require superior management skills, and managers will not only have to be attentive to costs, they will also have to manage technology much more effectively than they have in the past (Jacob and Kwak, 2003). The health care industry has the same competitive environment; hence, mobile communications technology is becoming an increasingly valuable tool in effective and efficient health care management. Increased efficiency in delivering critical



	2005/01	2005/02	2005/03	2005/04	2005/05	2005/06	2005/07	2005/08
Total tests	13344	14178	14190	12131	16372	19432	20962	18755
High risk tests	16	17	17	12	29	22	25	37
Rate	0.12%	0.12%	0.12%	0.10%	0.18%	0.11%	0.12%	0.20%

Fig. 6. High risk reports from the Radiology Department (2005/01–2005/08).

test results via mobile technology may expand quickly from laboratory, radiology, and pathology departments to emergency rooms, reducing emergency room patient risk and improving patient safety (Miller and McGowen, 2000).

Mobile communications technology assists health care providers in offering mobile services for inpatients and outpatients. With mobile patient safety services, physicians and nurses can get information regarding high-risk patients more quickly, protecting the patient's life. Furthermore, health care administrators can use the service to strengthen their management systems and thereby reduce their operating costs. Meanwhile, physicians and patients can quickly access and receive important information at any place and at any time. Therefore, patients will pay more attention to their health self-management and maintain a closer relationship with their health care provider.

Moreover, this technology can be utilized as part of patient health care management for chronically ill patients, contacting them for follow up examinations and for home care services. The application of mobile technology to improvement in PSS and in health care quality will no longer remain merely rhetoric, but will become a growing reality in the foreseeable future. Expanding mobile PSS domains will soon allow physicians to query patient databases and read full-text documents and view images or interactive diagnoses.

Similarly, mobile service helps health care providers to serve their patients better and at the same time simplify their complex administrative procedures. Moreover, it might contribute to preventive medical care. Mobile PSS not only improves the quality of health care service, but also enhances the patient's relationship with the health care provider. If its domain is enlarged, it has the potential to become a multi-functional health management agent.

The main contribution of mobile patient safety services will be to stimulate the growth of a new generation of mobile technology aimed at patient safety. Two future developments are suggested:

(1) Customized patient safety care for chronic patients. For chronically ill patients and their families, mobile communication services can be customized to meet their specific needs. For example, the system could be used for issuing reminders of pre-determined appointment dates, for following up treatment, and for distributing health maintenance information. Additionally, mobile communication services would allow chronically ill patients to look up their symptoms in hospital databases. These functions would facilitate increased levels of patient safety without greatly increasing hospital operating costs.
(2) Integration with hospital information systems. A synchronous integration of mobile patient safety services with the hospital information system would provide an interactive platform for patients and health care providers. Home care delivery and emergency medical services would benefit from mobile communication services as well.

The implementation period is an important stage of the innovation process that requires further investigation, but does offer some guidelines to practitioners (Linton, 2002). In order to improve mobile patient safety services, the present study recommends that researchers place more importance on the implementation period. A successful implementation is critical to gaining the competitive advantage that mobile patient safety services promises health care providers.

Mobile systems facilitate patient safety service improvement, but will be unavailable to people who do not have mobile devices. In order to provide comprehensive patient safety service, health care providers are expected to keep

improving services for all patients. For health care practitioners, this study proposes two critical issues for consideration: (1) *Medical staff workload and pressure*: How streaming patient information from cellular phone and e-mail might help to reduce medical staff workload and pressure is a critical issue. (2) *The inspection and maintenance of the PSS*: Health care providers will need to create a mechanism to maintain the stability and reliability of the PSS system. System unavailability, data integrity, and input errors are issues of concern that can be addressed by ensuring that medical staff carry out their tasks accurately and discuss abnormal test range revisions and new mobile patient service items periodically. In sum, continuous applying innovation mobile health technology is one critical factor to improving patient safety.

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