Mobile information and communication in the hospital outpatient service

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ABSTRACT

Objectives: Most healthcare providers provide mobile service for their medical staff; however, few healthcare providers provide mobile service as part of their outpatient service. The mobile outpatient service system (MOSS) focuses on illness treatment, illness prevention and patient relation management for outpatient service users. Initiated in a local hospital in Taiwan, the MOSS pilot project was developed to improve outpatient service quality and pursue higher patient safety.

Method: This study focuses on the development of the MOSS. The workflow, architecture and target users of the MOSS are delineated. In addition, there were two surveys conducted as part of this study. After a focus group of medical staff identified areas in which outpatient services might be improved by the MOSS, the first survey was administered to outpatients to confirm the focus group's intuitions. The second administration of the survey explored outpatient satisfaction after they used the MOSS service.

Results: With regard to outpatient attitudes, about 93% of participants agreed that the mobile outpatient service improved outpatient service quality. In the area of outpatient satisfaction, about 89% of participants indicated they were satisfied with the mobile outpatient service.

Discussion/conclusion: Supported by our study finding, we propose that more diverse mobile outpatient services can be provided in the future.

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1. Introduction

Healthcare services can be differentiated as either inpatient or outpatient. Outpatient healthcare is a vital component of the healthcare system and represents one of the strongest growth areas in the healthcare industry. Two-thirds of Taiwan's total national health insurance (NHI) expenditure is spent on outpatient services; hence, managing outpatient services is of great importance [1]. Outpatient service plays a major role in healthcare delivery in Taiwan.

In its report of "Crossing the Quality Chasm: A New Health System for the 21st Century", the Institute of Medicine (IOM) emphasizes the importance of patient safety [2]. Currently, in the realm of patient safety, most hospitals focus on devices, procedures, professionals and healthcare delivery systems to pursue patient safety [3]. However, there is room to apply advanced information technology (IT) to further pursue patient safety. Information technology has the potential to transform the delivery of care by streamlining processes, making procedures more accurate and efficient and reducing the risk of human error [4]. Retrospective studies have pointed out that most mobile technology contributed to medical care [3,5–8], as the mobile services and devices were designed based on hospital staff requirements. Yet, there are few cases of applying mobile services to enhance patient safety in terms of outpatient services. Therefore, this research seeks to develop an integrated system which especially applies mobile technology to patient safety as well as outpatient service.

Owing to technological advances in diagnostics, medication and procedure, most healthcare needs are necessarily handled on an outpatient basis [2]. Physicians and nurses are highly mobile in their hospital routine, moving frequently between outpatient clinics, therapeutic departments and operating theatres. Based on the physician's and nurse's workflow and mobility requirements, healthcare providers have adopted mobile technology to provide manifold medical information and improved communication channels. Currently, mobile information and communication systems play an important role in clinical routine. Mobile service has greatly improved communication [9], patient data entry [10], medical decision-making [5] and healthcare [11]. However, few healthcare providers employ mobile technology in their outpatient services. Outpatient services still have much room for improvement. For example, outpatients often wait for a long time at doctors' offices before receiving treatment; there is no reminder service for outpatient appointments; hospitals are unable to notify a large number of outpatients about lectures, give healthcare reminders or offer birthday greetings.

The population and the ratio of users' to use cellular phone numbers in Taiwan was 1:1.04 [12]. The high utilization of mobile communication is increasing dramatically each year. Most people are accustomed to communicating by cellular phone daily. The center of Patient Safety Informatics (PSI) in Wan Fang (W.F.) Hospital implemented the mobile outpatient service system (MOSS) to deliver manifold information to outpatients who owned cellular phone sets. The MOSS was also designed to send warning messages (e.g., abnormal laboratory test results) to physicians and administrators as well, thus, enabling the system to not only deliver high quality outpatient service but also to enhance patient safety.

2. Study aims

The illness treatment, illness prevention and patient relations management aspects of outpatient services still have room for improvement. W.F. Hospital implemented the MOSS to improve the outpatient service quality and it was the first hospital to provide mobile outpatient service in Taiwan. Hence, this study focuses on that institution's development of the MOSS.

The MOSS project consists of medical staff (administrators and physicians) and technologists; they suggested 18 functions of mobile outpatient services (Table 1). Before implementing the MOSS, this project investigated outpatient attitudes toward the proposed mobile outpatient services. After a 6-month experiment period, the project surveyed MOSS user satisfaction. In this study, we present the results mainly for outpatients from W.F. Hospital and we sought to answer the following questions:

Table 1 – The questions of questionnaire ranked by means

Question content, "Do you think the following notifications with mobile service is important?"	Mean	1, Very unimp (%)	2, Unimp (%)	3, Neutral (%)	4, Imp (%)	5, Very imp (%)
(1) Medication safety notification	4.3	0	1	6	55	38
(2) Pre-surgical operation notification	4.3	0	1	24	46	29
(3) Inpatient wards waiting notification	4.3	0	0	9	53	38
(4) Abnormal test result from check-up notification	4.2	0	0	13	51	36
(5) Pre-physical check-up and precaution procedure notification	4.2	0	1	12	57	30
(6) Pregnant women routine check-up notification	4.1	0	0	8	53	39
(7) Current treatment notification	4.1	1	2	21	43	33
(8) Pediatric disease vaccine service notification	4.0	0	3	25	43	29
(9) Pre-appointment patient reminder	4.0	1	2	17	56	25
(10) Pap smear notification	4.0	1	4	32	42	21
(11) Patient appointment inquiry	4.0	1	1	21	57	21
(12) Past due patient payment notification service	3.9	0	5	22	55	19
(13) Hospital adult check-up service notification	3.8	0	0	16	61	24
(14) Missed appointment notification	3.7	0	11	25	49	15
(15) Hospital community activities notification	3.4	0	8	54	29	9
(16) Lectures notification	3.4	0	11	49	33	7
(17) Physician and patient relationship management	3.3	2	12	51	21	15
(18) Birthday greeting notification	3.0	7	20	48	19	7

Imp, important service; Unimp, unimportant service. The means are on a scale of 1–5. Smaller values of mobile service indicated a lower importance of outpatient service, while larger values indicated a greater importance of outpatient service. Sample size: 102.

- The introduction of the MOSS system: what is the workflow of the MOSS? What is the architecture? Who are the service targets?
- Outpatient attitudes: what were the outpatient's attitudes before adopting the mobile outpatient service?
- Outpatient satisfaction: were the outpatient satisfied after receiving the MOSS service?

The followed sections are organized as follows: The introduction of the MOSS is described in Section 3. The analytical methodology is briefly described in Section 4. The results are presented in Section 5 and this study ends with the conclusions and a discussion.

3.   MOSS

3.1.   *Mobile technology applied in medical care*

Mobile technology has aroused considerable interest among service providers, users, vendors and content developers. For medical care providers, significant mobile advances have been made in devices, applications and networking infrastructure. For example, home care [11], ER service [3], user interface service [8], medical knowledge access [6], mobile patient information [5,7,8], mobile healthcare computing devices [13,14] and security services [15] have gradually been adopted by healthcare providers. More and more mobile tools and services have been developed.

To date, no hospital is actively providing mobile service for outpatients in Taiwan. Observing the current workflow of outpatient services, we considered the weaknesses of outpatient service that could be improved by mobile technology. This study portrays the practices outpatients, physicians and administrators:

(1) *Outpatients*, they often spend much waiting at inpatient ward counters to get into an inpatient ward. In addition, check-up and preventative services, patient relations management and patient safety service, all were difficult to provide with limited resources.
(2) *Physicians*, notification of emergent events such as adverse drug effects, patient falls, needle sticks, unknown fevers and others, sometimes reach the assigned physicians after hours.
(3) *Administrators*, they often move about in the hospital and they need to timely information to manage the hospital more efficiently.

3.2.   *The description of MOSS*

The workflow, architecture and target users of the MOSS are as follows:

3.2.1.   *The workflow of the MOSS*
Table 2 lists the service targets, service contents and execution of the MOSS. The MOSS was designed to contribute to illness

Service targets	MOSS service contents	Executions
Outpatients	1. Patient appointment inquiry 2. Pre-appointment patient reminder 3. Current treatment schedule notification 4. Missed appointment notification 5. Past due patient payment notification service 6. Pre-physical check-up and precaution procedure notification 7. Inpatient wards waiting notification 8. Pre-surgical operation notification 9. Medication safety notification 10. Pregnant women routine check-up notification 11. Hospital adult check-up service notification 12. Pap smear notification 13. Pediatric disease vaccine service notification 14. Abnormal test result from check-up/return to hospital for treatment service notification 15. Lectures notification 16. Hospital community activities notification 17. Physician and patient relationship management 18. Birthday greeting notification	Patients → MOSS MOSS → outpatients
Physicians	1. Notification of patient's abnormal lab result as well as other information to physicians 2. Notification of drug safety issues regarding individual patients 3. Group physicians notifications from Emergency room 4. Physician's lateness and help notification	MOSS → physicians
Administrators	The management of physicians and clinics	MOSS → administrators

Table 2 – The workflow of MOSS

treatment, illness prevention and patient relations management. The MOSS was an integrated system that served outpatients, physicians and hospital administrators. The MOSS not only provided messages through mobile cellular phones and Internet e-mails, but also provided voice notification for aging patients who were not familiar with the operation of cellular phone short messages. In the following section, the workflow of the MOSS was delineated from the aspect of patients, physicians and administrators, respectively.

The outpatient services content of the MOSS can be explained briefly as follows:

(1) *Outpatient appointment service.* The MOSS provided an automatic inquiry function to reduce waiting time. Patients were allowed to check on the status of current outpatient receiving. The service automatically sent short, voice phone messages and Internet mails to outpatients. The purpose was to inform the outpatient service status and how many patients were in line ahead of his/her appointment number. Related services are listed in Table 1.
(2) *Check-up and precaution service.* Some services were designed to remind the outpatient of precautions and procedures to follow before receiving physical check-ups or surgery.
(3) *Patient safety service.* These services provided safety warnings and reminders which were related to patient safety issues.
(4) *Patient relations management.* The service improved enhanced patient relations management through the delivery of messages via mobile cellular phone, voice mail and Internet. Most messages communicated the physician's concern about the patient's health, birthday greetings and lectures for improving patient health.

The physician's service contents of the MOSS are explained as follows:

(1) *ER notification*: Use of this function mobilized a group of physicians to the emergency room, sending trauma patient pictures and data through the MOSS before the patient arrived at the emergency room.
(2) *High risk reminder*: This played the important role of delivering critical radiology, pathology and other text reports to physicians.
(3) *Adverse events notification*: Through this function, physicians were notified of adverse drug events, patient falls, etc.

The administrator's service content of the MOSS included: daily financial revenue information, outpatient visit and inpatient bed occupancy rate notifications, ER daily patient visits information, OPD new patient visit information, self-pay and insurance reimbursement financial information and adverse events notification information. MOSS sent the above information to administrators, facilitating efficient hospital management.

3.2.2. The architecture of the MOSS

The MOSS was structured as follows. The MOSS offered a variety of functions to deliver mobile services to dedicated medical processes and patients. Six subsystem layers including hospital service-provider, presentation, system operators, medical processes logic, data access and database layers comprised the MOSS (Figs. 1 and 2).

(1) *Hospital service-provider layer*: This layer allowed for communication between administrators of hospitals, physicians and patients by means of e-mail, mobile messages, set top box, telephone, fax and Internet. The users of the MOSS were free to use mobile tools, capable of transmission on the Internet.
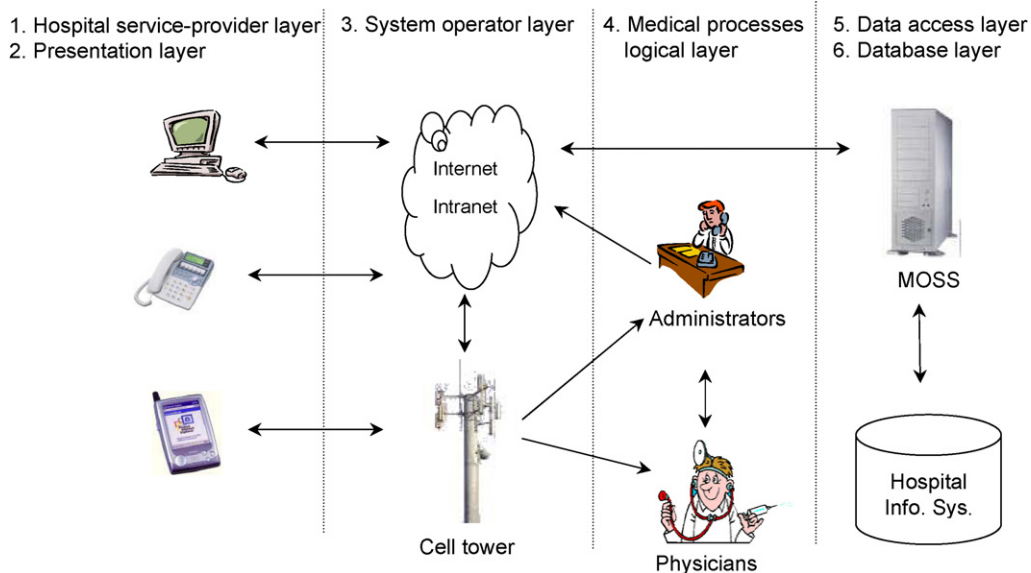(2) *Presentation layer*: Mobile tools dedicated to the MOSS allowed users to check messages from a visual menu. This

| 1. Hospital service-provider layer | 3. System operator layer | 4. Medical processes logical layer | 5. Data access layer |
| 2. Presentation layer | | | 6. Database layer |

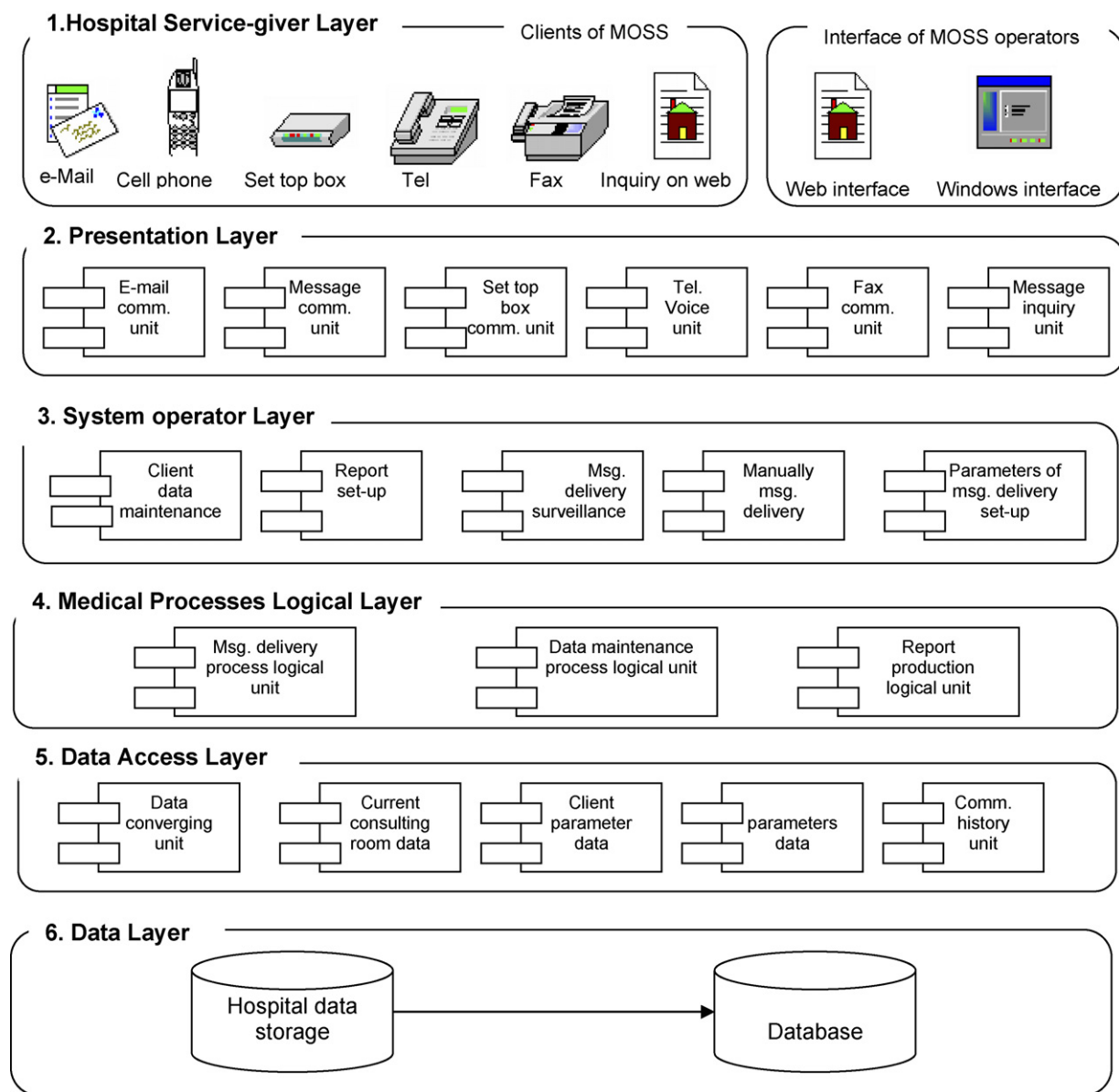**Fig. 1 – Diagram of MOSS architecture.**

Fig. 2 – The layers of mobile MOSS architecture.

layer communicated with e-mail, mobile messages, set top box, telephone, fax and Internet. This not only provided a visual menu for mobile tool users but also helped the operators of the MOSS deal with the maintenance of user menus, reports, monitoring message delivery, manual message delivery, parameters of the system and service requirements.

(3) *System operator layer*: This layer was an interface of communication between the MOSS system and system operators. The interface provided for connection with workstations, Window NT platform and web pages in order to support all hospital medical information.

(4) *Medical processes logic layer*: All MOSS system logical functions were integrated in this layer, which was the core unit of mobile service including a processing logical unit, data maintenance unit and report-producing unit.

(5) *Data access layer*: This layer provided stability and efficiency in accessing data, helping the MOSS to manage the medical processes logical layer smoothly. It consisted of the following functions: data insertion, in-time referral data, personal parameters, default parameters and a historical communication data function. All functions and parameters were executed in the application server without problems. In particular, MOSS reached highly accurate and consistent performance standards based on Microsoft COM+.

(6) *Database layer*: Any database utilizing the Microsoft .NET platform and ADO.NET was able to collaborate with MOSS system easily.

3.2.3. The target users of the MOSS

Fig. 3 shows the service items in the MOSS (outpatient reservation, outpatient registration and abnormal test results noti-
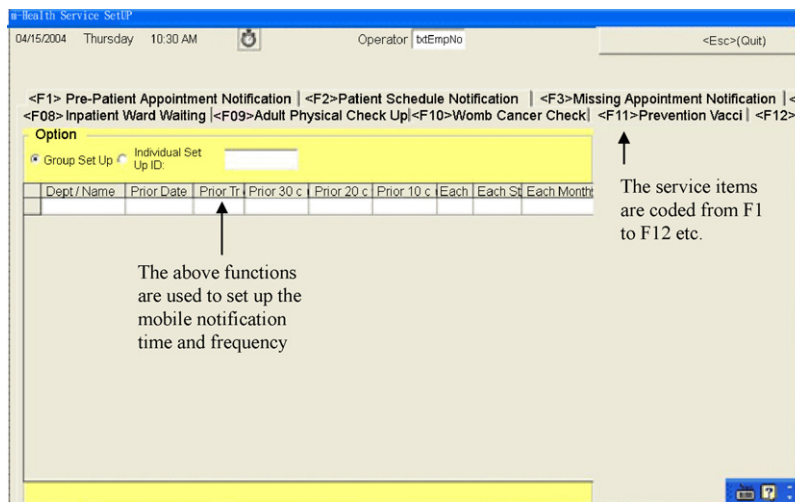
Fig. 3 – The operating chart from outpatient service of MOSS.

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fications and greetings). System operators were able to set up functions for outpatients and physicians. Fig. 4 shows the screen used to input short messages. The short message field allowed no more than 60 words. The system operator sent short messages to MOSS users by automatic or manual transmission.

In Fig. 5, the MOSS sent the dedicated outpatient personal outpatient treatment data automatically (examples include pre-physical check-up or surgery precautionary procedure notification service and birthday greetings). In Fig. 6, the short message sent from the MOSS reminded physicians to pay attention to outpatient waiting time; meanwhile, a short
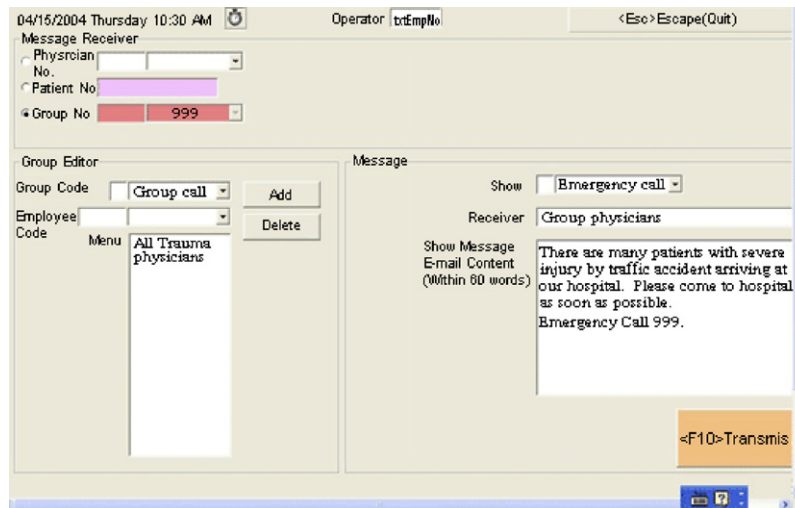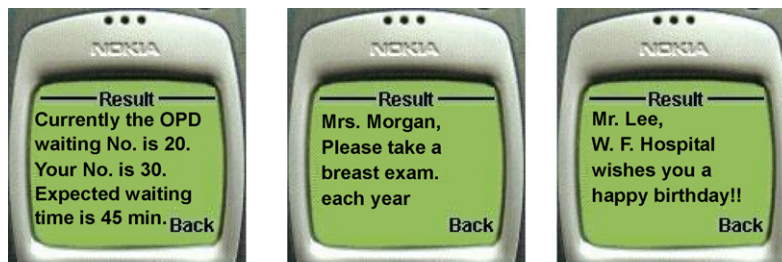

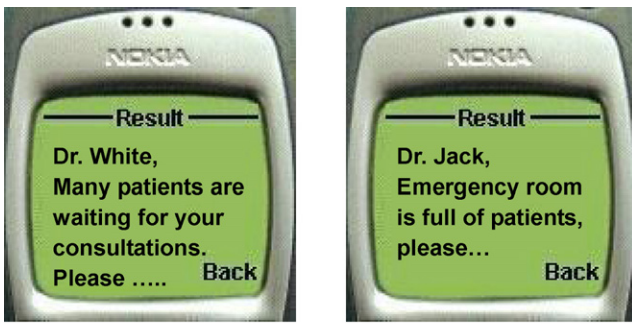**Fig. 4 – A short message being entered by a MOSS operator.**

Patient appointment notice   Patient safety reminding notice   Patient relationship management

Fig. 5 – Samples of the MOSS for outpatients.

Emergency calling   ER emergent calling

Fig. 6 – Samples of the MOSS for physicians and administrators.

MOSS reported to the administrator if the emergency room needed more physicians to treat outpatients.

4. Study design

4.1. Procedures

To answer the questions outlined in Section 2, there were two surveys conducted, one before and one after implementing the MOSS system.

4.1.1. Survey one
The project leaders considered that physicians and hospital administrators contact outpatients daily and that all of them understand the outpatients' needs. Hence, the MOSS team members comprised 11 physicians and administrators. Based on the medical staffs' experience and suggestions, the team designed various functions that focused on improving outpatient service. After completing the MOSS system design, the project team designed a questionnaire to measure outpatient attitudes toward adopting mobile outpatient services. The purpose of survey one was to explore whether the MOSS met outpatients' needs.

In January 2004, the MOSS project team designed the questionnaire, which contained 19 questions regarding outpatient services. The first 18 questions asked participants which mobile services they thought would be important to improving
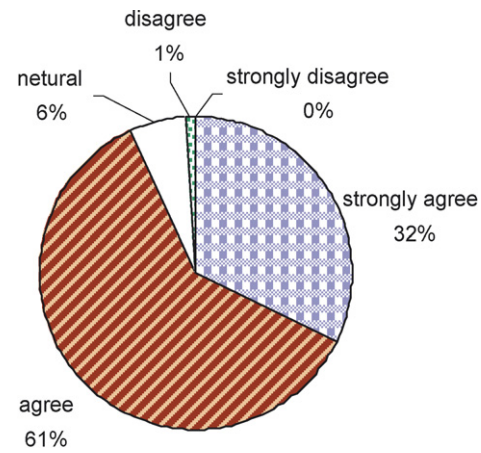

Fig. 7 – Responses of the participants to the 19th question of survey one questionnaire: "Do you think the mobile service will improve outpatient service quality?".

outpatient service quality (Table 1). The 19th question asked the participants if they thought that mobile services would be important to improving outpatient service quality (Fig. 7). The questionnaire adopted a 5-point scale to measure the participants' attitudes, 5 (very important/strongly agreed), 4 (important/agreed), 3 (neutral), 2 (unimportant/disagreed) and 1 (very unimportant/strongly disagreed). In addition, the participant's education, sex, age and personal cellular phone were surveyed.

4.1.2. Survey two
The second questionnaire was a telephone survey in which the MOSS users were asked three questions about their experience using the MOSS service (Table 3). The survey adopted a 5-point scale to measure each participant's satisfaction after using the MOSS service. Participants were asked to indicate whether they strongly agreed (5), agreed (4), were neutral about (3), disagreed (2) or strongly disagreed (1) with the survey statements.

4.2. Participants

In January 2004, before implementing the MOSS, 120 questionnaires were distributed in survey one, which had an 85%

Table 3 – The outpatient's satisfaction after adopting the MOSS						
Question content, "*According to mobile outpatient Mean service, do you. . ... .*"	Mean	1, Strongly not agree (%)	2, Not agree (%)	3, Neutral (%)	4, Agree (%)	5, Strongly agree (%)
(1) Feel satisfaction after receiving mobile . outpatient service.	4.2	0	0	13	54	33
(2) Desire to get mobile outpatient service . continuously.	4.3	0	0	13	46	41
(3) Think mobile outpatient service improving outpatient service quality.	4.4	0	0	7	50	43

The means are on a scale of 1–5. Smaller values of agree indicated a lower satisfaction for mobile outpatient service, while larger values indicated a greater satisfaction for mobile outpatient service. Sample size: 198.

response rate. From the analysis of respondent characteristics, the majority of participants were female (65%) and 82% of participants' educational background was beyond the high school level. Their average age was 39.2 years. Among the participants, 97% had cellular phones and over 82% of cellular phone users used the message and listened to voice message functions.

The PSI center employed the MOSS for 6 months from February to June in 2004. During the experiment period, the MOSS delivered approximately 10,300 service messages to 6700 patients from August 2004 to January 2005. In February 2005, survey two was conducted by telephone. A sample of 250 questionnaires were distributed and 198 questionnaires were completed. As the result, it had a 79% response rate. The majority of participants were female (58%), 67% of participants' educational background was beyond the high school level and the average age was 48.6 years.

4.3. Course of the study

The primary target user group of the MOSS is outpatients. Based on the original outpatient service workflow, the PSI Center identified out the 19 kinds of mobile outpatient service content to prompt responses to outpatient service quality. Thus, we were able to elicit from the participating outpatients not only information regarding their needs, satisfaction with services and contribution of the MOSS to outpatient services and patient care, but also their implicit suggestions for future mobile outpatient service.

5. Results

5.1. Survey one—outpatient's attitudes

Table 1 presents summary information ranked by means. The outpatient service means ranged from 4.3 (very important service being perceived) to 3.0 (neutral). In Table 1, we found that the means less than 4.0 were related to non-examination or non-medical outpatient services. In contrast, the means greater than 4.0 were related to examination or medical outpatient service. There were eleven types of service that were considered of significant importance.

According to the 19th question, Fig. 7 shows diverse opinions on the potential value of the MOSS. The results showed that about 61% of participants "agreed" that the MOSS would improve outpatient services and 32% "strongly agree." In sum, over 93% of participants agreed that the mobile outpatient service would improve outpatient service quality. Inspired by the results of survey one, the PSI Center was encouraged to implement the MOSS.

5.2. Survey two—outpatient satisfaction

Table 3 shows the agreement means ranging from 4.2 to 4.4, indicating that participants felt satisfied with mobile outpatient service, i.e., "Do you think mobile outpatient service will improve outpatient service quality?" This mean was the highest among the three questions. This might be attributed to the fact that MOSS users felt that with the mobile system

they could better manage their healthcare at no additional expense. In brief, this study concludes that the MOSS may have met the outpatients' expectations.

6. Discussions

The results of questionnaires imply that most outpatients care about the quality of outpatient services. Healthcare providers may consider offering more mobile medical care services for their patients. Improvements in the areas of timesavings, operational efficiency, missed appointment rate and overall outpatient service quality can be attributed to MOSS use. The main contribution of the MOSS may be as a stimulant to the growth of a new generation of mobile hardware and software with more outpatient service functions. We would like to propose some suggestions for the future development of mobile outpatient systems:

6.1. Customized care for chronic patients

For chronic patients and their families, mobile services can be customized to meet these specific needs, such as providing reminders or warnings on dedicated dates. Additionally, adapting mobile service could look up chronic patient's symptoms from hospital databases. These foreseeable functions will facilitate improvement in patient safety without greatly increasing hospital operational costs.

6.2. Integrating clinical information systems into MOSS

The systematic integration of clinical information is a critical component in most hospitals. It operates the clinician order entry, interactive clinical data repository systems, multidiscipline documentation and point-of-care (POC). Applications might be integrated into a system that could be utilized for future development of mobile outpatient services.

6.3. Integration of mobile tools into hospital information systems

A synchronous integration of mobile tools and hospital information systems provide an interactive platform for patients and hospitals. Home care delivery and emergency medical service (EMS) could benefit from mobile services as well. Following, we provide three possibilities. (1) Emergency medical services (EMS): first-aid personnel forward patients' data to dedicated hospitals before they reach the emergency room. Hospital information departments might get the patient's care records over XML-based systems in cases where the patient's care records do not belong to a particular dedicated hospital. (2) Citizen health system (CHS): we suggest that some chronic patients be equipped with mobile global positioning, system-enabled tools. This will assist these chronic patients when confronted with any sudden situations and allow EMS to know where the patients are. (3) Patient safety: IT ensures streamlined processes for patient safety and makes the processes more accurate and efficient. The

powerful functions of mobile service drastically reduce the risk of human error. EMS providers could access data from referral information systems, EMS databases and others; additionally, patients could access data from hospital databases by following directions provided by a referral information system.

6.4. Developing a new generation of mobile hardware and software

Various tools for mobile information processes and communication are commercially available at present. The ability of currently available personal digital assistants (PDA), display and text input devices (mostly pen-based) and mobile computers (pen-based notebook computers and laptops, virtual terminals, etc.) to communicate with and integrate into hospital information systems can be expected in the near future. In other words, hospital mobile services coordinated with mobile tools dedicated for patients are diffusing and assimilating and this will encourage more patients to adopt mobile services from hospitals for more efficient, higher quality service.

7. Conclusions

The conclusions of this study were based on outpatient service, physician patient care and administrator's managerial perspectives.

Traditionally, the missed appointment rate of outpatients in W.F. Hospital was around 15–17%. Forgetting appointments and having to wait too long were main reasons for missed appointments. After the 6-month experiment period, the MOSS helped the missed appointment rate drop to around 5%. The MOSS not only improves outpatients' missed appointment rate, but also reminded outpatient to get regular physical check-ups.

After adopting the MOSS, severe abnormal test results reached the physicians effectively, saving from 72 to 30 h. Meanwhile, the utilization rate of adverse events notifications increased 500% because the medical staff were able to provide instant care after they received the adverse events notification. For physicians, the MOSS increased the patient safety. For managers, the MOSS provided managerial notifications and reports. Based on the MOSS reporting data, the administrators enhanced their response time in dealing with all crises and improved hospital management.

With fast and far-reaching changes, mobile technology plays the role of promoting patient safety in various fields of medical care and promotes patient service. In the future, we will expand the MOSS functions in outpatient services, which will play the role of a multi-functional healthcare agent to increase healthcare service quality in an era of mobile outpatient services.

Acknowledgements

Summary points

What was known before the study

- Mobile technology can meet the dynamic workflow requirements of medical care providers in their clinical routine.
- Inability to foresee daily outpatient caseload leads to long waits for patients and affects the quality of care provided.
- At present, it is difficult to deliver various patient notifications and to manage patient relations.

What the study has added to our knowledge

- Employing cutting-edge technologies, mobile healthcare service is able to provide various notifications to patients and (by providing real-time waiting line updates) to decrease waste of outpatient time.
- Mobile healthcare service delivers important information to patients, medical staff and healthcare administrators more quickly than conventional telephone or paper systems, reducing risk to patients.
- In areas with high mobile communication use, healthcare providers can utilize mobile technology to create and maintain systems for provider-patient communication which promote closer provider-patient relations and increase patient safety.

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