

# The Uses of the Smartphone for Doctors: An Empirical Study from Samsung Medical Center

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**Objectives:** In healthcare, mobile computing made possible by smartphones is becoming an important tool among healthcare professionals. However, currently there is very little research into the effectiveness of such applications of technology. This study aims to present a framework for a smartphone application to give doctors mobile access to patient information, then review the consequences of its use and discuss its future direction. **Methods:** Since 2003 when Samsung Medical Center introduced its first mobile application, a need to develop a new application targeting the latest smartphone technology was identified. To that end, an application named Dr. SMART S was officially launched on December 22nd, 2010. **Results:** We analyzed the usage data of the application for a month until April 25th, 2011. On average, 170 doctors (13% of the entire body of doctors) logged on 2.4 times per day and that number keeps growing. The number was uniformly distributed across all working hours, with exceptions of heavy accesses around 6-8 AM and 4-6 PM when doctors do their regular rounds to see the patients. The most commonly accessed content was inpatient information, this constituted 78.6% of all accesses, within this 50% was to accesses lab results. **Conclusions:** Looking at the usage data, we can see the use of Dr. SMART S by doctors is growing in sync with the popularity of smartphones. Since u-Health seem an inevitable future trend, a more rigorous study needs to be conducted on how such mobile applications as Dr. SMART S affect the quality of care and patient safety to derive directions for further improvements.

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## I. Introduction

In healthcare industry, mobile computing allowed by smartphones is becoming an important tool and has grown in popularity among health care professionals during the past 5 years [1,2]. The smartphone is much more than just a phone [3]. Basically it is very useful for doctor as a personal organizer with calendar and a communication tool with email account. The latest smartphone has a built-in high quality camera. This could potentially be used in the emergency setting to photograph injuries or lesions. Common examples of other popular applications (apps) are osiriX, which allows doctors to view radiology images, Pubsearch, which provides access to millions of journals indexed in Pubmed, Epocrates, which services information on dosages, interactions, contraindications as well as images of drugs, and iDoc which con-

tains 20 medical textbooks [3]. Other examples of information and communication technology (ICT) convergence on the smartphones are “Voalte One” and “Zone Service,” which combines phone calls, text messaging, and alarm alerts all in one device, simplifying the communication between the health professionals [3,4]. In practice, many hours of doctors’ time have been wasted trying to refer a patient [3]. Thus there are moves to provide doctors with apps in order to provide collaborative and efficient patient care. Doylestown Hospital at Pennsylvania and Mount Sinai Hospital at Toronto recently developed in-house iPhone apps that give doctors secure, remote access to patient records, test results, vital statistics, medical reference apps, and breaking health alerts [5,6]. They enable doctors to make critical treatment decisions, whenever and wherever they want [7].

There is very limited research evidence which influences

academic circles, although those case studies were reported on the vendors’ brochure. This study aimed at presenting a framework of smartphone apps running on Google’s Android in order to give doctors mobile access to patient information, review consequences of its use and discuss its future direction. In this paper, we described the technical framework in the detail and summarized the results of its use after its adoption into our clinical setting. At the conclusion, we discussed on directions in the future researches.

## II. Case Description

Samsung Medical Center (SMC) was founded on November 9, 1994 under the philosophy to contribute to improving health of the nation through the best medical service, the advanced medical research and development of outstanding medical personnel. SMC is an academic, nonprofit tertiary care hospital with 1,951 sickbeds where approximately 6,500 staffs including over 1,200 doctors and 2,000 nurses are working. Equipped with the advanced medical service infrastructures, such as the outstanding medical staff, Samsung Medical Information System (SMIS), picture archiving communication system (PACS), clinical pathology automation system and logistics automation system, SMC is leading the new hospital culture in Korea by being the best hospital in high-tech medical services and providing the patient-

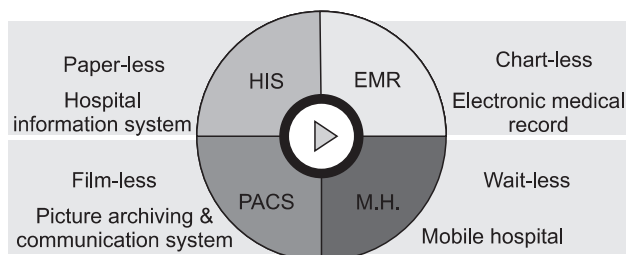


Figure 1. Strategy of information technology.





Period	2003. 8~2006. 7	2006. 8~2008. 7	2008. 8~2010. 8	2010. 9 ~
Phone	SCH-M3300	SPH-M4300	SCH-M480	SHW-M110S
(Brand)	- MITs	- MITs	- Mirage	- Galaxy S
(Maker)	- Samsung	- Samsung	- Samsung	- Samsung
(OS)	- Palm OS 3.5.2	- Windows mobile 2003	- Windows mobile 6.1	- Android 2.2 Froyo
App. Main Menu	mSMIS 1.0 	mSMIS 2.0 	mSMIS 3.0 	Dr. SMART S 

Figure 2. History of mobile application on smartphones. MITs: mobile intelligent terminals, OS: operating system, App.: application, mSMIS: mobile Samsung Medical Information System.

centered medical services in the genuine sense. SMC attends to about 8,500 outpatients per day, has an average of 1,800 inpatients daily, and performs about 160 complex surgical procedures every day in 2011.

### 1. History of Mobile Application on the Phone

SMC has established four strategic objectives in information technology (IT) (Figure 1). They include paper-less through hospital information system (HIS), chart-less by virtue of electronic medical record (EMR), and film-less by PACS, all of which are common in the healthcare industry. The last one “wait-less” is, however, unique and rarely found elsewhere. A smartphone app named “Dr. SMART S,” which SMC has developed and deployed in the real clinical environment, is an example of that strategy.

It was August, 2003 that SMC introduced a mobile app for the first time (Figure 2). At that time, it was rare for hospital to introduce “Zone Service” using smartphones as part of an effort to realize fixed mobile convergence (FMC) [4]. The first app was developed to run on the Palm OS, which was adapted to Samsung smartphone, “SCH-M3300.” Since then, the app was upgraded by 3 times. The first upgrade was for migration from Palm OS to Windows OS. However, the latest upgrade was for both restructuring content and moving to Google Android. SMC also renamed the app as Dr. SMART S, in that it might help doctors be smarter on the smartphone, “Samsung Galaxy S.” The contents provided by Dr. SMART S include information of inpatient, outpatient, patient at operating room and patient at emergency room, consultation notes, and patient list waiting to admit. Those are what doctors always want to know although they roam around here and there leaving their offices. It is a microcos-

mic version of SMIS. There were few changes during last 8 years.

### 2. Technical framework

Dr. SMART S is made up with major 3 components, terminal, network infrastructure, and server group, at the technical framework level (Figure 3). The terminal is a kind of smartphone which can have downloadable apps run on the OS. SMC has used Samsung Galaxy S as terminal, which loads Dr. SMART S run on Google Android. The app was developed using Eclipse IDE (Platform 3.5). SMC makes full use of both wireless and wired network as network infrastructure [8]. The end point connected by terminal wirelessly is Aruba Access Point (AP-70, IEEE 802.11 a/b/g). The wired is composed of backbone switch (10 Gbps) at computer room, distribution switch (1 Gbps) from computer room to every floor, and workgroup switch (100 Mbps) at every floor. Major component of server group is mobile server which retrieves data from legacy system and provides them to terminal. The legacy system stores transaction results on SMIS and responds to mobile server’s request. Authentication server between mobile server and legacy system controls users at the security level. OS and database management system (DBMS) on the mobile server are Windows Server 2003, and MySQL 5, respectively. Development tool for mobile server software module was NetBeans 6.0. Legacy system uses Hewlett-Packard Integrity Superdome as hardware, HP-Unix 11.23 as OS, TMAX 4.0 as middleware, and Oracle 10g as DBMS, respectively.

### 3. Algorithm and Content Structure

In order to execute Dr. SMART S, the app has to be down-

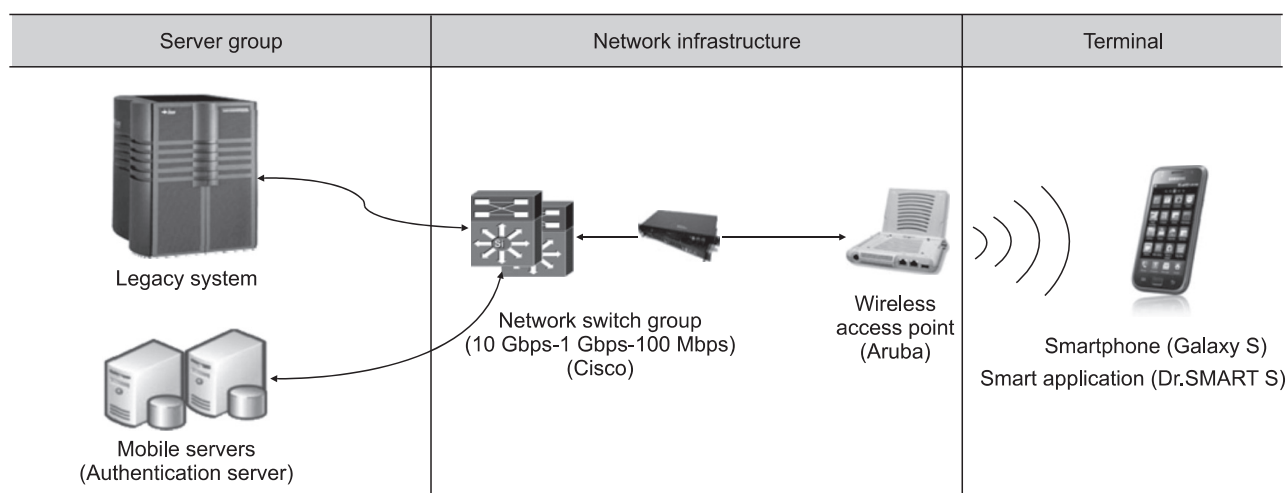


Figure 3. Framework of Dr. SMART S.

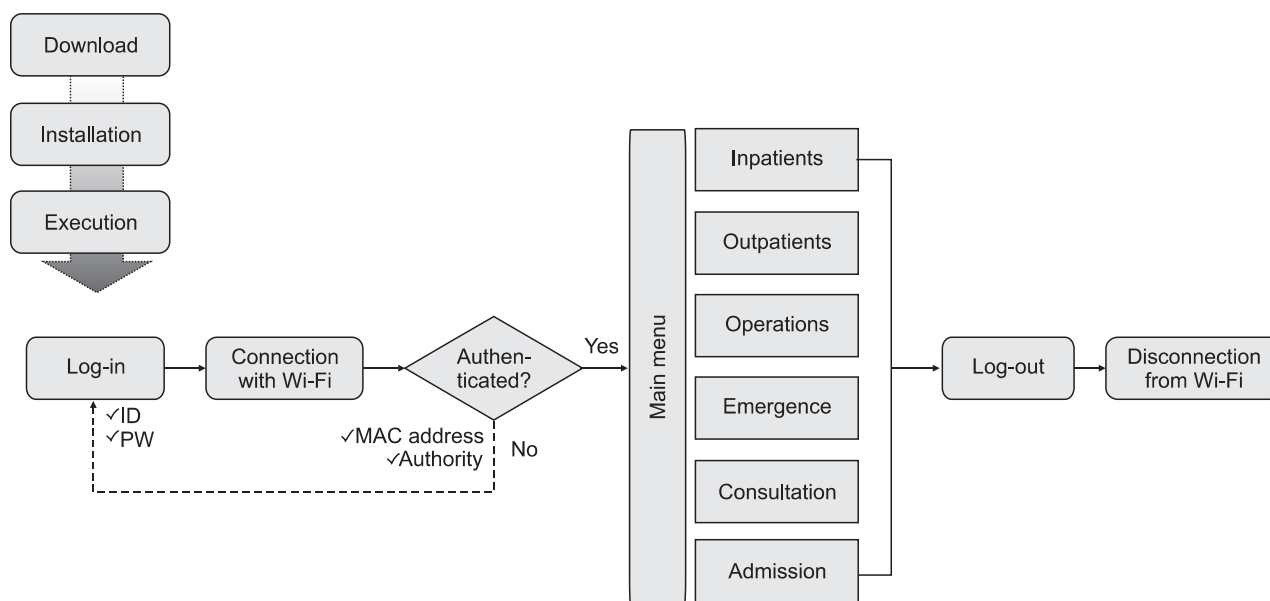


Figure 4. Algorithm and content structure. MAC: media access control.

loaded into smartphone. Login screen is displayed in the case of pushing app’s icon. Identification (ID) and password (PW) entered into login screen are encrypted and transferred to mobile server through wireless network. The wireless connection is made by the app even though users don’t know network preference. This connection process is two levels of user authentication since media access control (MAC) address of terminal is compared with information of legacy system along with ID and PW check [6]. The two levels of user authentication enable to prevent not-allowed user’s access although a phone is lost [9]. The encryption of data packet maintains the confidentiality of any patient data communication between terminal and server group. The information from ID or MAC address gives users the authority to access patient data with their own level. The terminal is automatically disconnected from network in the case there is not any action on the terminal for a certain period of time which is set by SMC’s policy. After login, the app displays default screen organized by 6 main menus. Details of patient information are displayed on the phone when pushing one of them. The algorithm for using Dr. SMART S and its overall content structure is shown in Figure 4.

A barrier which must be overcome is poor network coverage within hospital service area [9]. SMC installed the wireless network AP at every care floor, lobby, and cafeteria, where doctors mainly go around within hospital.

### III. Results

In June, 2010, SMC formed task force team (TFT) in order to develop mobile apps that meet doctors’ needs. TFT was composed of doctors from internal medicine and surgery as the primary user group; and IT technicians including developers and graphic designers. An initial set of user needs were drawn from the TFT meetings. Then TFT went around the whole hospital area in order to judge whether the needs were adequate to the real clinical setting and defined the final set of requirements. In August, 2010, TFT developed a prototype of display layouts based on the requirements. Since September, 2010, TFT started to develop smartphone application named “Dr. SMART S,” based on the requirements and display layouts. In November, 2010, TFT distributed the developed application to the members of task force and tested its functions in detail. After accommodating software bugs and other requests for improvements identified in the testing stage, Dr. SMART S was officially launched on December 22nd, 2010.

#### 1. Contents

The Login screen where ID and PW can be entered pops up when a user selects the Dr. SMART S app icon from the smartphone display (Figure 5A). Then a default screen consisting of 6 main menus is provided if the login process succeeds (Figure 5B). The menu labeled as “inpatient” shows a list of inpatients together with their names, doctors, and other clinical information such as main disease and infec-



Figure 5. Examples of contents. (A) login, (B) main menu of Dr.SMART S, (C) inpatient list, (D) vital signs of patient, (E) order & progress, (F) lab examination, (G) consultation notes, and (H) calling consuler.

tion (Figure 5C). When one of inpatients is selected, the buttons labeled as “Vital Sign,” “Order,” “Examination Results,” “Images,” and “EMR” are displayed. Vital sign contains vital information for the last two days. It is displayed as a graph or a table (Figure 5D). Orders contain information on drugs, examinations and treatments. It is set to drug information by default (Figure 5E). In case of laboratory examination, the numeric values are colored as red or blue depending whether they cross the thresholds or not. It helps doctors grasp the patient status easily and quickly (Figure 5F). Consultation note, one of the 6 main menus, allows doctors to communicate one another for consultation (Figure 5G). By pressing a dial button, one can directly call the other doctor (consuler) for questions (Figure 5H).

The size of a smartphone display is so small that TFT decided to restrict contents only to view but not to enter data.

Since PACS on the smartphone was not approved by the government at the time, TFT did not provide the service although the function itself had already been implemented.

After opening the service, the information access is continuously increasing so that the number reached 405 by 170 users, about 2.4 access per user, on the last day, April 25th, 2011 (Figure 6). The number of accesses, 405, is increased about 4 times from 40 of the beginning day. Although the number of users is also increasing in time, there is little change in the average number of daily accesses per user that is about 2.1 (Figure 6, access per user). The total number of users reached 680. The accesses by top 10 heavy users constitute 12.2% of the total amount, although they were only 1.5% of the total users. The average number of daily accesses per user by the heavy users was about 5.4 that is over 2 times that of average users.

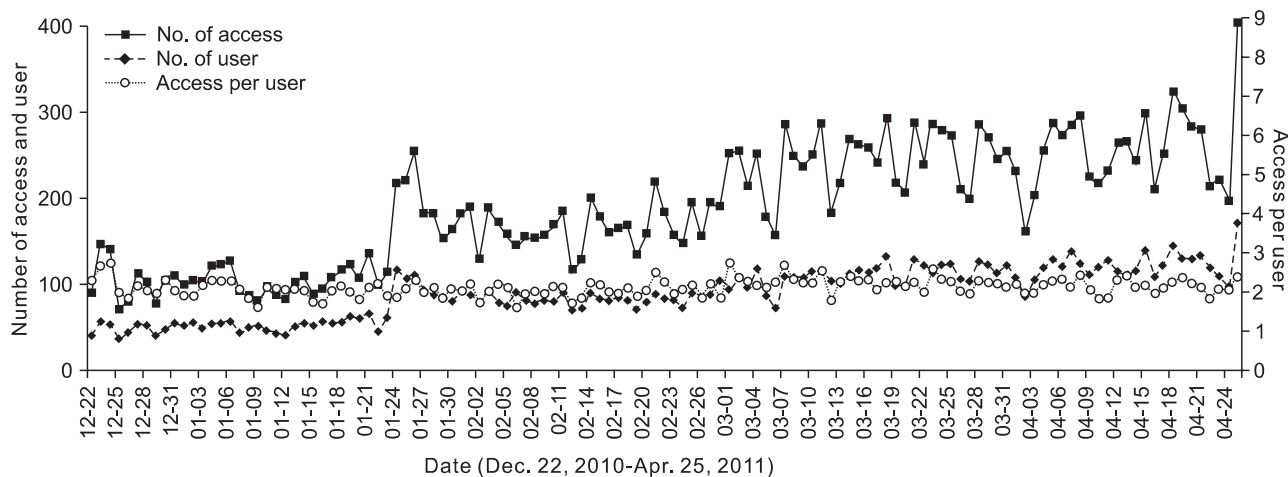


Figure 6. The trend of access since service opening.

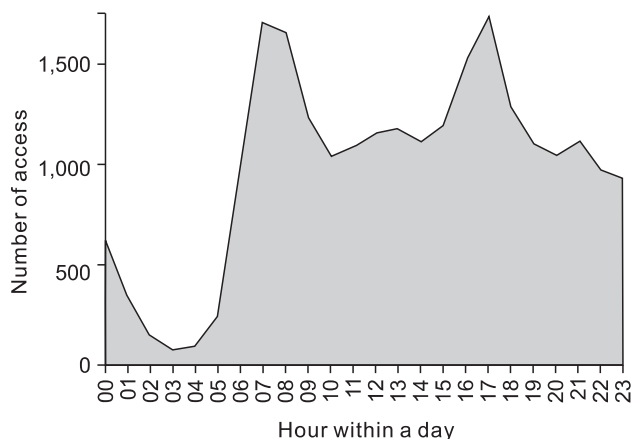


Figure 7. The access pattern of daily access.

The peak times of access were 6-8 AM and 4-6 PM (Figure 7), which can be explained by the fact that doctors tried to view the information of patient prior to ward rounding. That assumption was supported by the contents view status. The most heavily viewed content was the inpatient information constituting 78.6%. Of inpatient information, the examination result was the most popular content (Table 1).

**2. User Feedback**

Doctors were generally satisfied in that they could retrieve the information on their patients with ease and could respond quickly upon emergence calls during conferences or other work loads. They particularly expressed higher satisfactions with the fact that they could readily consult through Dr. SMARTS S when they needed clinical helps from doctors of other specialties. The usage data reveals that the access pattern varies among specialties and ages of doctors. The specialties that most heavily used the application include:

Table 1. The contents view status

Contents	Details	No. of access	%
Inpatients	Examinations	33,440	
	Patient lists	14,892	
	Vital signs	10,452	
	Orders	5,593	
	Electronic medical record	5,505	
	Infections	123	
	Subtotal	70,005	78.6
Emergency	Patient lists	3,961	
	Orders	1,937	
	Vital signs	50	
	Electronic medical record	34	
	Examinations	1	
	Subtotal	5,983	6.7
Consultation		5,117	5.7
Operations		5,067	5.7
Admission		1,695	1.9
Outpatients		1,170	1.3
Total		89,037	100

1) General Surgery (15.5%) that typically conducts rounds of visits to the patients right after surgeries; 2) Pediatrics (12.8%); and Cardiology (8.7%) that frequently checks vital signs of patients. In terms of age, residents and junior staff who are in their 20s (39.5%) and 30s (43.8%) were turned

out to be the heaviest users and their combined access constituted 83.3% of the total access.

They also said, however, some doctors didn't know the availability this useful smartphone application or how to download it into their smartphone. Thus they suggested that more public announcements about Dr. SMART S need to be made so that more doctors could learn about it. Other complaints include the lower performance of smartphones compared to that of personal computers and the narrow wireless network coverage.

There was a strong demand for the capability of accessing PACS images. According to many, if they can view PACS images of postoperative patients whenever and wherever they want, this application could maximize the efficiency of clinical decision support.

#### IV. Discussion

In this paper, we presented our experience of the development, implementation, and deployment of Dr. SMART S that is a smartphone app for Google's Android mobile platform that allows doctors for access to patients and their medical information from anywhere within SMC, anytime. As such, it can greatly improve the quality of care as well as achieves the "wait-less" objective in SMC's IT strategy. A unique contribution of our study is that it is one of the early studies on smartphone apps for the use in the real clinical setting with the analysis on their usage.

As Nolan [9] observed, the trend of growing usage of smartphones inevitably indicates just how important they have already become to day-to-day lives of doctors and other clinicians. As such, smartphone apps can be innovative gadgets in doctors' pockets and, with the increasing demand of information by doctors, offer ample opportunities to improve the quality of care as well as the patient safety. Further comprehensive analyses of user usage patterns would lead to customized applications and services that meet user requirements and are used at points of care better.

Nonetheless, there are obstacles that must be addressed before smartphone apps can indeed help doctors and other clinicians make better clinical decisions. An example of such barriers is PACS: recently a plan to legally revitalize the use of mobile PACS has been proposed, but there still remain practical regulatory barriers such as banning access from outside of hospitals [10]. While the majority of people agree that those apps can greatly enhance the use of health information for better healthcare, they also express concerns over information security and protection. These concerns should be addressed by adopting appropriate technology solutions

as well as improving security-awareness of people who use the mobile technology.

Finally, the most important observation we make is that, in the long run, the mobile health applications will lead to a new model of healthcare service coupled with state-of-the-art technologies, regardless of their short-term success or failure in the market. One of the most representative examples is the ubiquitous health service, in which smartphones play a pivotal role that relays all sorts of health information data between various kinds of portable health devices such as glucose meters and health information services monitored by physicians. Therefore, we must constantly investigate opportunities for improved quality of care and patient safety offered by smartphone apps such as Dr. SMART S and conduct rigorous analyses on the outcome of the use such apps.

#### Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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