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Impact of encounters on patient app use: results of a tethered mobile personal health record usage pattern analysis

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Abstract

Introduction The adoption of tethered mobile personal health records provides not only medical information to patients but also various convenience functions related to hospital use, thereby increasing accessibility to healthcare services and promoting patient engagement. We analyse the tethered mobile personal health records app's usage logs to determine how it can contribute to improving medical service accessibility and patient engagement.

Methods Log data, that comprised menu type, log time, and date, were collected from the mobile personal health records app of a tertiary referral hospital. Clinical information, including patients' demographics and visit type, was collected from the clinical research warehouse system. The usage log was analysed in terms of the type of visit, service function, and time period.

Results Outpatients accounted for 34% of the total app usage and was the most app-accessed visit type. The most utilized menu functions were lab test and visit schedule for visits or non-visits. For Inpatient and Health check-ups, menu usage patterns showed a focus on lab test results. While investigations and other menu usage showed double peaks in the morning and afternoon, peak usage of lab test results correlated with inpatient blood sampling times, which was around 9 am.

Discussion App menus to access health information, particularly blood tests, emerged as the most accessed menu. Hence, when compared with blood sampling times and hospital information system usage patterns, encounters occurring in the hospital majorly impacted patient app use. For improved patient engagement, improving lab test function should be the priority.

Keywords MHealth, Mobile health, Personal health record, PHR, Convenient features

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Introduction

With the advancement of information technology (IT), the desire to enhance patient engagement by providing access to a wide range of information, anytime and anywhere, for the benefit of patients, has witnessed a growth in the healthcare sector [1, 2]. Surveys have consistently shown that patients express a strong desire to use personal health records (PHRs) and recognize their value [3]. If designed appropriately and widely adopted, PHRs could reduce costs while simultaneously improving the safety and quality of care [4].

In healthcare institutions, PHRs enable patients to access data generated in healthcare facilities [5]. Subsequently, patients gain the opportunity to manage, control, and utilize data to their advantage. Furthermore, PHRs offer a deeper understanding of a patient's health status, providing more precise and clinically relevant patient information in addition to granting insights into a patient's well-being between medical appointments [6, 7]. Today, the emergence of mobile PHR (mPHR) apps has made data more accessible, allowing unrestricted access to PHRs without the constraints of time and location [8].

mPHRs can offer services encompassing medication management, alternative communication methods (beyond face-to-face interactions), appointment coordination, educational resources, and self-health monitoring [5]. In a medical institution, an mPHR not only allows patients to access healthcare-related features but also permits patients to pay medical bills from their mobile devices [9]. Features, such as scheduling medical appointments, requesting medication refills or renewals, receiving preventive care reminders, and receiving personalized care plans, are provided to enhance the quality of patients' daily lives [10]. As such, considering the benefits that can be obtained from PHRs across various medical institutions, tethered (connected) mPHRs are receiving greater interest.

A tethered mPHR is linked to a specific healthcare organization's electronic health record (EHR) system or a health plan information system [11]. Although a tethered mPHR is expected to contribute to shared decision-making, quantitative research on the value of PHRs in patient engagement is lacking [12]. While conducting research utilizing logs from PHR operated by the government is expected to be challenging, it is likely to be easier with tethered PHRs. Nonetheless, research examining the correlation between patient encounters (such as types and timing of visits) and PHR usage (such as types of menus accessed and login times) is limited.

By comparing the usage rates of various services offered through PHRs, such as informational resources and convenience features, we can identify those services with the highest demand. Additionally, by taking into account the unique characteristics of tethered mPHRs, we can examine how service demand varies with patient circumstances (e.g., visit type) and hospital operating hours. Our primary aim is to analyze menu usage patterns among patients using a specific hospital-provided tethered mPHR app: My Chart in My Hand (version 2.0, MCMH 2.0). This analysis will demonstrate how effectively tethered mPHRs engage with users as tools supporting the patient journey.

Materials and methods

Data sources

We gathered log data from MCMH 2.0 at Asan Medical Center (AMC), where MCMH 1.0 was first implemented on December 27, 2010, following collaboration with a South Korean telecom company (SK Telecom Co. Ltd., Seoul, Republic of Korea) [13]. The app is applicable in diverse clinical scenarios, including cancer, inflammatory bowel disease, diabetes, paediatric asthma, and atopy following medication consultations with a clinical pharmacist [13]. The usage of MCMH 2.0 is not limited to AMC patients; any patient can download the app and utilize the functions associated with the aforementioned patient-generated health data. However, only patients are permitted to use functions linked to the AMC hospital information system.

We collected data available from MCMH 2.0 consisting of numerous logs, including menu logs, which contained member IDs, log dates, log times, log types, and information regarding the services accessed by patients. Log data were available from September 28, 2020, to March 30, 2021. The sample included 145,549 patients. Figure 1 shows the screenshot of MCMH 2.0's main menus when people accessed the app after logging in. We also collected the visit days and patients' basic demographics through the EHR from the Asan Biomedical Research Environment (ABLE) system, a service offered by the Asan Medical Information System, a pseudonymized clinical data warehouse [14].

Data and statistical analysis

To ensure a more precise classification of menu types, we categorized them by their main functions, the titles of which are available on the main screen. Additionally, to determine the menus accessed by patients during their visits to AMC, we established specific rules for each visit type. For inpatient and emergency visits, we considered the dates when the patient visited AMC to be the period in between, including the date of admission and the date of discharge. For health check-ups and outpatient visits, we only included the date when the patient visited AMC for hospitalization. However, patients undergoing health check-ups were excluded from the analysis of menu usage due to their low percentage (1%), which had minimal influence, and the uncertainty of lab test results

	🔻 🛋 🛢 07:53		💎 🔺 🛢 07:53		💎 🔟 🛢 07:53
🗮 My Chart in My Har	nd ۞	🔶 Health Managem	ent 🏫	← wвс	业 🍙
Home Diabetes Pec Care Asthm	diatric Health na/Atopy promotion	Blood pressure & Pulse rate	Blood glucose level	2015.04.10	4.7 x10 ³ /uL
My chart He m	ealth anagement	120/90 mmHg 44 bpm	50 mg/dL	2015.02.24	5.3 x10 ³ /uL
c 💼		Body mass index 25.61 kg/m ² 170 cm / 74 kg	Risk of cardiovascular disease 10% (Low-risk group)	2014.11.05	4.1 x10 ³ /uL
My S Medication Diary	y Schedule			2014.10.19	4.8 x10 ³ /uL
	(F)	Metabolic syndrome Not applicable		2014.10.19	5.7 x10 ³ /uL
OPD He	ealth neck-up			Exam Date	Result Measure
Reservation	eservation			Exam Date	Result Measure
	f 🔰 🚾			Exam Date	Result Measure

Fig. 1 Screenshot of MCMH 2.0

 Table 1
 Demographics table for app users during the study period

	Total (n = 145,544)
Gender	
Female	76,617 (53%)
Male	68,927 (47%)
Birth Year	
1920s	60 (0%)
1930s	1,625 (1%)
1940s	9,930 (7%)
1950s	26,510 (18%)
1960s	31,355 (22%)
1970s	30,494 (21%)
1980s	25,646 (18%)
1990s	12,202 (8%)
2000s	3,182 (2%)
2010s	4,124 (3%)
2020s	416 (0%)
Mobile Device	
Android	113,466 (77%)
iOS	34,372 (23%)
Visit Type	
Emergency	5,100 (4%)
Health check up	1,950 (1%)
Inpatient	10,076 (7%)
Outpatient	64,532 (44%)

being checked on the same or the following day [15, 16]. We analysed the data using Python (version 3.8.5).

Results

Data introduction

A total of 11,046,779 menu log entries were recorded. The outpatient category exhibited the highest frequency of menu log entries, with a total of 3,787,280 logs. Inpatient visits accounted for 1,804,903 logs, while there were 210,453 logs for emergency visits and 11,415 logs for health check-up visits.

Demographic traits

Table 1 displays the baseline demographic traits of individuals who used the app during the study period. The gender distribution was nearly equal between females and males, and the patients were predominantly born between the 1950s and the 1980s. Additionally, a significant majority (approximately three-quarters of the patients) used Android rather than iOS devices. Approximately half the app users' visits during the study period were of the outpatient clinic visit type. Inpatient visits, emergency visits, and health check-ups accounted for 7%, 4%, and 1% of visits, respectively.

Menu usage

Table 2 presents the five most frequently accessed menu types across different visit types, including both

Rank	Not visiting (<i>n</i> = 70,231 ^ª) (log count/ log per person)	Visiting (n = 47,932) (log count/ log per person)	Outpatient (n = 46,809) (log count/ log per person)	Inpatient (<i>n</i> = 7,058) (log count/ log per person)	Emergency (<i>n</i> =2,821) (log count/ log per person)
1	Lab test	Lab test	Lab test	Lab test	Lab test
	(2,942,161/ 41.9)	(4,578,021/95.5)	(2,865,452/ 61.2)	(1,537,217/ 217.8)	(175,352/ 62.2)
2	My schedule (1,163,143/ 16.6)	My schedule (601,472/ 12.5)	My schedule (505,921/ 10.8)	My schedule (82,741/ 11.7)	My schedule (12,810/ 4.5)
3	Outpatient appointment booking (423,409/ 6.0)	Outpatient appointment booking (113,483/ 2.4)	Outpatient appointment booking (82,941/ 1.8)	Outpatient appointment booking (26,286/ 3.7)	Outpatient appoint- ment booking (4,256/ 1.5)
4	Medication information (203,435/ 2.9)	Medication information (90,910/ 1.9)	Medication information (66,108/ 1.4)	My Chart Disease History List by Department (21,180/ 3.0)	Medication information (3,648/ 1.3)
5	My health record (136,769/ 1.9)	Payment history inquiry (56,878/ 1.2)	Payment history inquiry (42,197/ 0.9)	Medication information (21,154/ 3.0)	My Chart Disease His- tory List by Department (2,058/ 0.7)

Table 2 Difference among the five most accessed menu types regarding type of visit





Fig. 2 Percentage of usage in hours between lab test and investigations and other menus throughout the day on weekdays for each visit type (the orange dotted vertical lines are the regular blood time at inpatient admittance)

non-visits and visits, which encompasses outpatient, inpatient, and emergency visits. For the first four mostaccessed menus, non-visiting and visiting menu choices are identical. As 98% (46,809/47,932) of people who used the app during visits were outpatients, the five most accessed menu types between visiting patients and outpatients are similar. Furthermore, patients with emergency, inpatient, and outpatient visits had identical top three most accessed menu types. Visiting patients accessed the lab test twice as often as the non-visiting patients. However, the remaining menus did not show a substantial difference compared to lab test. Outpatient and emergency visit patients accessed lab tests a similar number of times during the study period; however, inpatients accessed lab tests approximately 3.5 times (217.8 / 61.7) more frequently. Except for lab tests, most menus had a similar amount of per-person menu access among outpatients, inpatients, and emergency patients.

Figure 2 illustrates the percentage of usage in hours between lab tests and investigations and other menus throughout the day on weekdays for each visit type. On a weekday, for lab tests, outpatients showed a more gradual peak from 8 to 11 am, while inpatients showed a sharp peak at 9 am. It is evident that patients of the inpatient visit type mostly accessed both lab tests and other menus after their regular blood time. In contrast, for outpatients, investigations and other menus showed a double peak at around 10 to 11 am and 2 pm on weekdays. Moreover, especially in inpatients, investigations and other menus showed a gradual peak on weekdays compared to weekday peaks from lab tests. For lab tests, investigations, and other menus, on weekdays, emergency patients did not show a significant trend.

Table 3 presents the usage of lab tests and other menus categorized by the type of visit and the hour type on weekdays and weekends. For outpatients, 55% (2,061,928/3,700,751) of the data logs were created during weekday morning working hours, while very few (19,607/3,700,751) were created at any time during the weekend. Moreover, for outpatients, during the morning working hours, lab test had approximately four times (426,644/123,774) more menu usage per hour compared to the afternoon/evening working hours. For inpatients, for both weekdays and weekends, the difference between

Table 3 Lab test and other investigation counts

		Inpatient (<i>n</i> = 7,058)		Outpatient (n = 46,809)		Emergency (n = 2,821)		Non-visit (<i>n</i> = 70,231)	
		Lab Test	Others	Lab Test	Others	Lab Test	Others	Lab Test	Others
Weekday	Working hour AM	526,902	51,328	1,706,574	355,354	35,931	6,385	664,287	512,760
	(8 am-12 pm)	(131,726)	(12,832)	(426,644)	(88,839)	(8,983)	(1,596)	(166,072)	(128,190)
	Working hour PM	206,846	44,172	742,645	279,724	34,231	6,145	599,504	530,344
	(12 pm-6 pm)	(34,474)	(7,362)	(123,774)	(46,621)	(5,705)	(1,024)	(99,917)	(88,391)
	Non-working hour	362,572	61,090	390,910	205,937	57,530	9,650	845,579	775,686
	(6 pm-8 am)	(25,898)	(4,364)	(27,922)	(14,710)	(4,109)	(689)	(60,399)	(55,406)
Weekend	Working hour AM	110,746	9,790	1,580	1,555	5,447	868	130,289	91,572
	(8 am-12 pm)	(27,687)	(2,448)	(395)	(389)	(1,362)	(217)	(32,572)	(22,893)
	Working hour PM	49,343	7,933	5,074	2,085	7,299	1,145	105,597	100,260
	(12 pm-6 pm)	(8,224)	(1,322)	(846)	(348)	(1,217)	(191)	(17,600)	(16,710)
	Non-working hour	79,641	11,438	6,515	2,798	133,207	2,183	200,930	202,727
	(6 pm-8 am)	(5,689)	(817)	(465)	(200)	(9,515)	(156)	(14,352)	(14,481)

The values in parentheses are the number of each menu log divided by the amount of time for that group

lab test's usage and that of other menus during morning working hours was approximately 10 times (e.g., 131,726/12,832) higher. Furthermore, for inpatients, the menu usage ratio between lab test and other menus was moderately consistent, despite the difference in hours between weekdays and weekends. For all visit types, including non-visit, over half of the menu access occurrences per time for both lab tests and other menus were during morning working hours. The menu usage per hour was highest for morning working hours, followed by afternoon/evening working hours; it was the lowest during non-working hours, regardless of the type of visit or day of the week.

Discussion

Statement of principal findings

In this research, we analysed the log data from the MCMH 2.0, a tethered mPHR application for AMC, to compare visit types and trends of menu usage. Our findings revealed that outpatient visits had the most menu activity on the app, and that the most frequently accessed menu options, regardless of the visit type, were viewing lab tests, checking one's schedule, and booking outpatient appointments; lab tests were accessed twice as frequently as the next most accessed menu, My Schedule. The timing of menu access showed a clear correlation between peak usage hours and blood sampling hours for lab tests, and investigation, and other menus. Additionally, over half of the menu usage occurred between 8 am and 12 pm when calculated per hour, irrespective of menu type and day of the week.

Strengths and limitations

Several studies have demonstrated that patients primarily accessed lab test results through mPHR [16–19]. However, our study is the first to reveal real-time access patterns of menus within the mPHR. This finding is significant because it elucidates how patients navigate and utilize the interface of their mPHR, providing valuable insight for improving user experience and healthcare delivery through mobile platforms.

One limitation is that the tethered app is offered by AMC, a territorial hospital, where the majority of the patients are South Korean; this may introduce bias. Furthermore, the data were only accessible in approximately six-month intervals, as the app was built for patient convenience, not for research. Consequently, it may not comprehensively represent the usage patterns of all patients following the creation of the app, potentially introducing bias into the selection criteria.

Interpretation within the context of wider literature

Despite the addition of numerous convenient functions within the app, the lab test menu was used most frequently by the patients. This could be due to the information offered in this menu. Among the outcomes routinely accessed by patients through tethered apps, blood lab tests were the most common. Patients tend to perceive favourable blood lab tests as indicators of good health. These results serve as a means to screen for serious health conditions, and are influenced by societal factors and media portrayals, contributing to an overestimation of the significance of blood tests in assessing overall health [16].

Individuals may also check lab tests frequently due to short appointment times; turnover time is rapid, with five-minute consultations common in South Korea [20]. Particularly in the case of outpatients, as the time spent with the doctor is brief, patients may perceive the amount of time as insufficient to address their concerns and fulfil their needs. To overcome this issue, MCMH 2.0 employs colour coding for abnormal results, providing patients with a visual reference range, and is equipped with an information button to offer general insight into a conducted test. However, the offered information may be insufficient for patients, which may lead to them searching the internet for explanations and information regarding their lab tests. In one study, approximately 63% of patients received no explanatory information or interpretation when they initially received their results, and 46% resorted to online searches to seek additional information [17]. Moreover, patients want to not only view their medical information, but also manage their health [19]. Therefore, lab test results may be the menu most associated with patients' health regardless of their visit type.

Even as hospitals contemplate the need for educational materials, patients often proactively seek out information on their own [18]. Additionally, providing direct access to services for testing and results has led to high rates of follow-up treatment and has lowered the threshold for testing in patients. Therefore, though the initial intended use of the tethered was not for patient support, it evolved naturally in that direction, where it could lead to higher patient engagement.

Additionally, the menu for lab tests was typically accessed more frequently in the morning on weekdays. The regular blood sampling time for AMC inpatients is approximately between 6 and 8 am, and the results are usually available on the app about one hour after the sampling. As such, patients can generally access the results around 9 am. This implies a relative peak around this time, especially for inpatients, as there is no fixed time for emergency patients' blood sampling, leading to a more even distribution throughout the day.

The graph for lab tests usage in hours has a similar shape for inpatients and outpatients on weekdays. This finding is similar to that of Kim et al.; though they conducted a study on apps for doctors, the similarity of the working hours between patients at the hospital and doctors resulted in similar characteristics [21]. The standard blood sampling time for inpatients in the morning starts around 6 am every day, and regular working hours of the blood test lab for outpatients on weekdays are between 6:30 am and 6:30 pm. Considering the one hour from blood collection until lab tests are available, we can discern that most users checking the results during the morning peak are aware of this workflow and are appropriately using mPHR as a tool. For doctors, mobilebased electronic medical records have a peak interval use at around 6-10 am. Furthermore, we observed that the peak for inpatient activity typically occurred just before doctors' rounding time, which is the primary window for face-to-face patient-doctor meetings throughout the day. Therefore, it can be concluded that inpatients sought to review their lab test results around the time they consulted with their doctors.

Implications for policy, practice and research

Our study suggests that the menu accessed most frequently by patients was that for lab tests. However, patients do not necessarily receive explanations or benefits from the hospital directly when looking at their lab tests via the app [22]. Therefore, offering interactive functionalities could benefit both patients and healthcare providers. Moreover, healthcare policies should stress the need for comprehensive patient education regarding their medical data, which could lead to deeper patient engagement and help patients make more informed decisions. Hence, through a comprehensive analysis, we aimed to present approaches that could be implemented for tethered mPHRs to elevate the patient's overall experience, foster increased patient engagement, and facilitate datadriven decision-making on behalf of patients.

Conclusions

This study examined the menu usage pattern of a tethered mPHR app, MCMH 2.0. The app demonstrated a predominant focus on lab tests, particularly blood test outcomes. Despite the availability of various functions within the app, patients consistently accessed the lab test menu, suggesting a strong interest in monitoring their health status. Moreover, the peak usage hours for lab tests aligned with the typical blood sampling time for inpatients. Furthermore, throughout the day, over half the menus were accessed between 8 am and 12 pm irrespective of menu type and day of the week. As hospitals consider updating mPHR apps, prioritizing key functionalities on the main screen, especially those related to lab tests, can be crucial for optimal usability and engagement.

Abbreviations

ABLE	Asan Biomedical Research Environment
АМС	Asan Medical Center
EHR	Electronic Health Records
IRB	Institutional Review Board
IT	Information Technology
МСМН	My Chart in My Hand
mPHR	mobile Personal Health Records
PHR	Personal Health Records

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Authors' contributions

YT: Conceptualization, Formal analysis, Writing - Original Draft, Writing -Review & Editing, JHK: Conceptualization, Resources, Writing - Review & Editing, JL: Conceptualization, Writing - Original Draft, Writing - Review & Editing, YL: Conceptualization, Formal analysis, Writing - Original Draft, Writing - Review & Editing.

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Data availability

Mobile phone data are proprietary and confidential. We obtained access to these data from the Research Information Unit of Asan Medical Center

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB) of the Asan Medical Center, South Korea (approval No. 2022 – 0603). MCMH is a service designed to assist in medical treatment. The notice and consent for the use of personal information are disclosed in the terms and conditions of the application. The data analyzed in this study were collected retrospectively and processed under pseudonymization. Consequently, explicit consent from the participants was not obtained.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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