An analysis of patient portal utilization: What can we learn about online patient behavior by examining portal click data?

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Abstract (150 words)

This paper presents a study of online patient portal utilization through the analysis of system logs. We analyze click data generated between August 2009 and July 2011 by 1,886 users of an online patient portal. We investigate variations in utilization for *Login* and the top five system features (*Appointment Review*, *Lab Tests*, *Medical Advice Request (MAR)*, *Messaging*, and *Result Component Graphing (RCG)*), and examine how age and gender influence these variations. Our findings indicate that the effects of age and gender on system use vary by feature, and that efficiency of use (how clicks are spread across sessions) varies across age, gender and feature. We provide a new approach for understanding system use through click data analysis utilizing system logs (an underutilized data source available to all healthcare organizations), an example of how big data can help healthcare organizations learn more about their patients' utilization of patient portals.

Keywords: Patient Portals, Personal Health Records, System Use, System Logs, Age, Gender

Introduction

Patient portal implementations in the United States have been multiplying due to Meaningful Use criteria that require eligible professionals (EP) to communicate with their patients through secure electronic messaging and to "provide patients the ability to view online, download and transmit their health information within four business days of the information being available to the EP"[1]. Meaningful Use objectives were developed by the Centers for Medicare and Medicaid Services (CMS) and the Department of Health and Human Services (DHHS) in response to the Health Information Technology for Economic and Clinical Health Act (HITECH). HITECH authorizes "incentive payments through Medicare and Medicaid to clinicians and hospitals when they use EHRs privately and securely to achieve specified improvements in care delivery" (Blumenthal and Tavenner, 2010). To collect incentives through the Meaningful Use program, healthcare organizations need to prove with evidence from their EHR system that they met a number of objectives outlined by CMS and DHHS. A Meaningful Use Stage 2 objective requires healthcare organizations to prove that a certain percentage of their patients are signed up for a patient portal, with a smaller percentage of those patients actually using the portal. The Meaningful Use Stage 3 goals require further utilization of these systems to engage patients and their families in their care.[2] However, research on patient portal adoption is not conclusive about the factors that influence adoption and continued utilization of these portals by patients. Some studies reported that patients have different interest levels in selected portal functions (Wakefield et al., 2012). A recent review reported that to achieve more widespread use, studies should investigate the effects of demographic factors on utilization of patient portals (Goldzweig et al., 2013). It is therefore of great value for healthcare organizations to understand not only which portal is best for them and how to implement it, but also how to engage their patient populations in portal use given the varying interests in portal functions.

Recent studies indicate that patients show greater interest in utilizing patient portals when they see value in them such as the ability to help manage medications better

[1] https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Downloads/Stage2Overview_Tipsheet.pdf
[2] http://www.healthit.gov/providers-professionals/how-attain-meaningful-use

(Osborn et al., 2013), and that even in underserved populations there is interest in utilizing patient portals regardless of age, gender and race (Sanders et al., 2013). However, other literature suggests that there is variation in patient portal adoption among different clinics (Wald, 2010), potentially due to differences in patient demographics, systems in use, marketing practices, and provider and management attitudes towards these portals.

In this paper, we present a case study of patient portal utilization for a particular health system. We investigate patient portal system use logs from an analytical point of view and report our findings about the differences in system utilization patterns based on gender and age. We contribute to the literature by (1) demonstrating how to leverage existing system log data sets to gain a better understanding of utilization patterns, and (2) providing unique insights concerning the relationships among age, gender and patient portal utilization from exploring this valuable data source.

Previous studies of patient portal use examined the overall system constituents (Wald, 2010), general use patterns in terms of which features are used by the patients (Osborn et al., 2011), and how the number of users increased over time and which techniques were helpful in driving these increases (Goel et al., 2011). Although the knowledge accumulated about patient portal use and adoption was useful for new implementations, these studies were limited in the level of analysis they conducted to understand system utilization. The purpose of our study is to extend knowledge on patient portal utilization at a more granular level through new hypotheses, together with the analysis of click data from system logs, to shed light into the preferences of users and how they choose to use patient portals.

Previous Studies Reporting System Use

Individuals gain better access to their own healthcare data and become stewards of their own information through the use of patient portals (Halamka et al., 2008). The features available in current patient portal systems provide users with access to health information, billing information, medical histories, medication lists, and laboratory test results, together with the ability to view and change appointments, refill medications and transmit secure messages to the provider team. Existing studies reported that the most

popular features of personal health record (PHR) systems include Lab Test Results, Secure Clinical Messaging and Medication Refills (Halamka et al., 2008, Ralston et al., 2007, Weingart et al., 2006). Moreover, for individuals with chronic illnesses, personal tracking tools and disease specific features were also reported to be valuable (Bryce et al., 2008). A recent study reported that patients who enroll in these systems have different demographic characteristics and different interest levels for each feature in the system (Wakefield et al., 2012).

According to a public opinion survey conducted by Markle Foundation in 2008, 79% or more of the public believed using an online PHR would provide major benefits in managing health and health care services for individuals (Connecting for Health, 2008). Individuals may choose to use these systems if they provide a means of communication without the hassle of actually visiting the physician, thereby saving time and money. Physicians and patients, however, differ in their preferred means of communication. For example, an online survey of registered users of the MyChart portal by Geisinger Health System found that patients preferred a combination of e-mail and in-person communication, whereas physicians preferred a combination of in-person and telephone communication (Hassol et al., 2004). Patient demand for email contact with physician practices is increasing. Physicians, however, are often hesitant to use email with patients (Menachemi et al., 2011), largely due to concerns relating to workload, security and lack of compensation (Brooks and Menachemi, 2006, Ye et al., 2010), and moreover they are advised to be conservative in email use due to legal concerns (Kuszler, 2000). There have also been promising results achieved by some health systems such as Kaiser Permanente, which reports decreased rates of primary care office visits and telephone contacts due to the secure messaging feature of the patient portal (Zhou et al., 2007).

While there is agreement in the literature that patient demographics and health status affect patient portal use, there is a lack of agreement concerning the effects. On one hand, some studies report high PHR usage statistics for patients with chronic illness, disabilities and caregivers of elderly parents (Sprague, 2006). PHRs empower these users by helping them manage an accurate health record history accessible by any provider, for example in the case of an emergency where they may be unconscious (Lafky and Horan, 2011). On the other hand, a study investigating the profile of patient portal users

concluded that those who choose to use the portal "were younger and more affluent and had fewer medical problems than non-enrollees" (Weingart et al., 2006). This digital divide was also present in a recent survey reporting that higher-income individuals are the most likely to have used a PHR (Undem, 2010). This same study, however, also reported that "lower-income adults, those with chronic conditions, and those without a college degree are more likely to experience positive effects of having their information accessible online" (Undem, 2010). Gender and age effects have also been reported. For example, women are more rapid adopters of patient portals than men, and those aged 40-69 have the most rapid adoption rates (Carrell and Ralston, 2006). A recent study pointed out a number of differences in the use and adoption of consumer health technologies among different age groups (LeRouge et al., 2014), including the increasing interest in personal health management and higher readiness to use websites and email for health management among baby boomers.

Although these studies shed light into the effects of demographics on the overall patient portal adoption, they do not provide detailed insights into utilization patterns (as measured by mouse click counts) and differences in feature-specific patterns based on gender and age. Our study explores at the system use level the effects of age and gender on portal logins as well as on specific features (the top five features utilized in the system) by investigating the following hypotheses.

Effects of Gender:

H1. There is no difference in system feature utilization at the level of cumulative use or sessions of use between genders.

H2. There is no difference in system feature utilization at the level of cumulative use or sessions of use between genders within a particular age group.

Effects of Age:

H3. There is no difference in system feature utilization at the level of cumulative use or sessions of use between age groups.

H4. There is no difference in system feature utilization at the level of cumulative use or sessions of use between age groups within a particular gender.

Methodology

Overview of Study Site and Patient Portal System

Our field site is a multi-site, multi-specialty group medical practice located in the northeast United States, with approximately 250 physicians and 1,500 other employees. It serves 200,000 patients with over one million patient visits per year. The group practice has 25 clinic locations that utilize a well-respected electronic health record (EHR) system, providing features to support ambulatory care clinics and a patient portal. The patient portal, which is a tethered PHR, was made available to all clinic patients starting in the summer of 2009. The patient portal offered various features to the users as illustrated in the screen shots provided in Figure 1.

My Medical Record menu provides patients with submenu options to view test results, graph lab values, review allergies, immunizations, preventative care status, medical history, current list of medical issues in the EMR, and monitor health trends. The patients can add personal notes regarding their medical record through each submenu, but these notes are not shared with their providers.

The Message Center menu allows patients to send messages to their clinical team, to request medical advice or medication renewals, request appointments and initiate an "E Visit", a portal based encounter using questionnaires about simple acute health issues, such as back pain or UTI. Through this menu, patients can also send messages to customer support and billing departments. The Appointments menu enables patients to view past or upcoming appointments and to request or cancel appointments and for some providers directly schedule an appointment. The My Family's Records menu allows proxies to access other family members' records or setup proxy access privileges. Billing and Insurance provides insurance summary, and the Administrative menu allows patients to view terms and conditions, provide administrative information and setup a wallet card with a summary of important health history items. The My Profile menu allows patients to change their password, address and email address. Finally Health Library allows

patients to search for health information using a knowledge base approved by the health system.

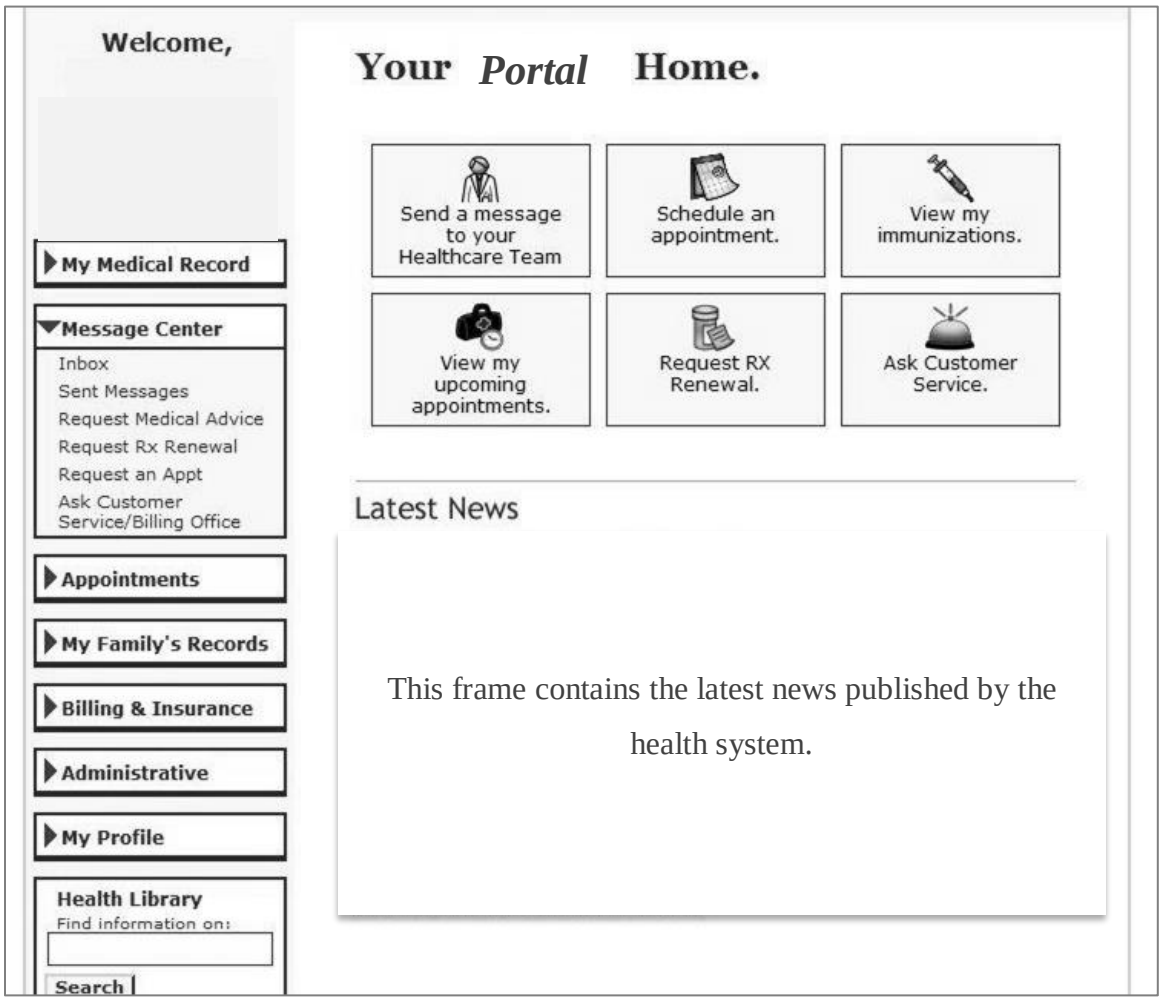

Figure 1 - Patient Portal Interface

Data Collection

The participant pool for this project was composed of patients of seven primary care physicians (PCPs) who agreed to participate in a research study about electronic medical records. The total panel size for these seven providers exceeded 17,000 patients. The subjects included in our analysis were those patients who joined the online patient portal sometime between August 2009 and July 2011. No major changes to the patient portal were implemented during this period.

This study was approved by the IRB of the medical center. The medical center analysts used unique subject numbers that were generated solely for this study to identify

different users in the patient portal. The data shared with the researchers did not have any personally identifiable information.

At the onset of our data collection, the portal was recently launched and was available to all patients who were willing to sign themselves up by physically going into one of the facilities to receive a sign-up code. During the first month of our data, only 543 patients of the seven PCPs had signed up for the system, corresponding to approximately 3% of the total patient panel. At the end of our data collection period, this percentage climbed to 11%, reflecting a total of 1,886 patients who became users of the patient portal, for these seven providers. These patients accounted for a total of 583,473 clicks over the 24-month study period. As illustrated in Figure 2, the number of clicks per month increased as more patients signed up for the portal. On the other hand, the average number of clicks per active user (a patient who logged into the portal in a given month) had a slightly downhill trend, potentially indicating increased familiarity with the system, as illustrated in Figure 3.

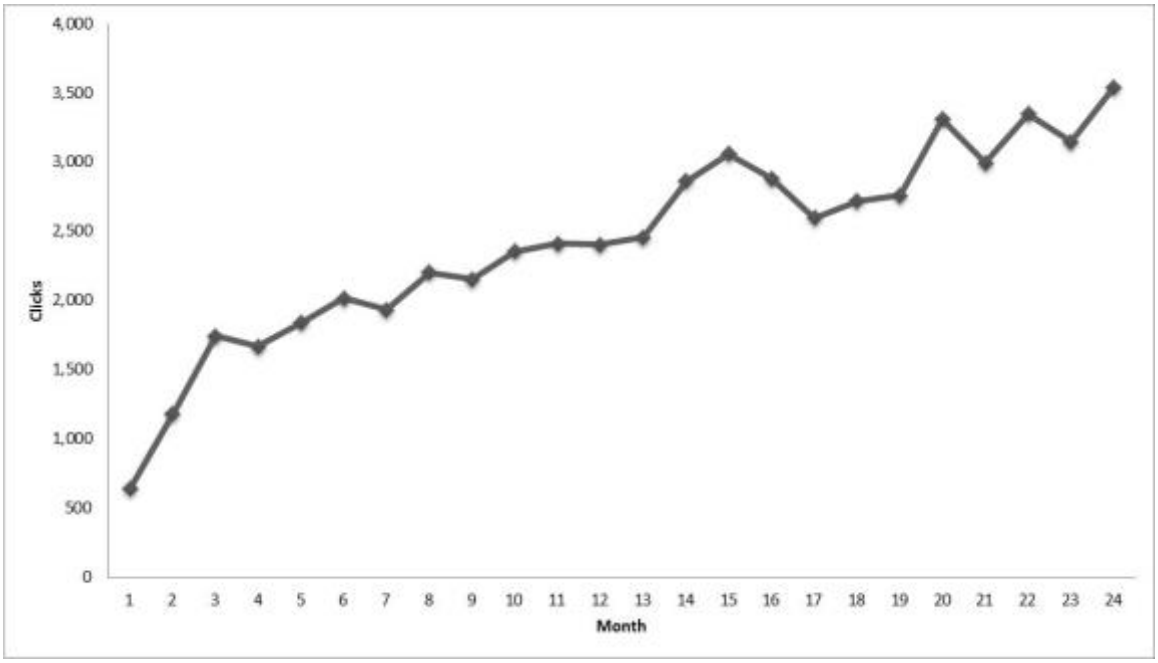

Figure 2 - Number of Total Clicks per Month

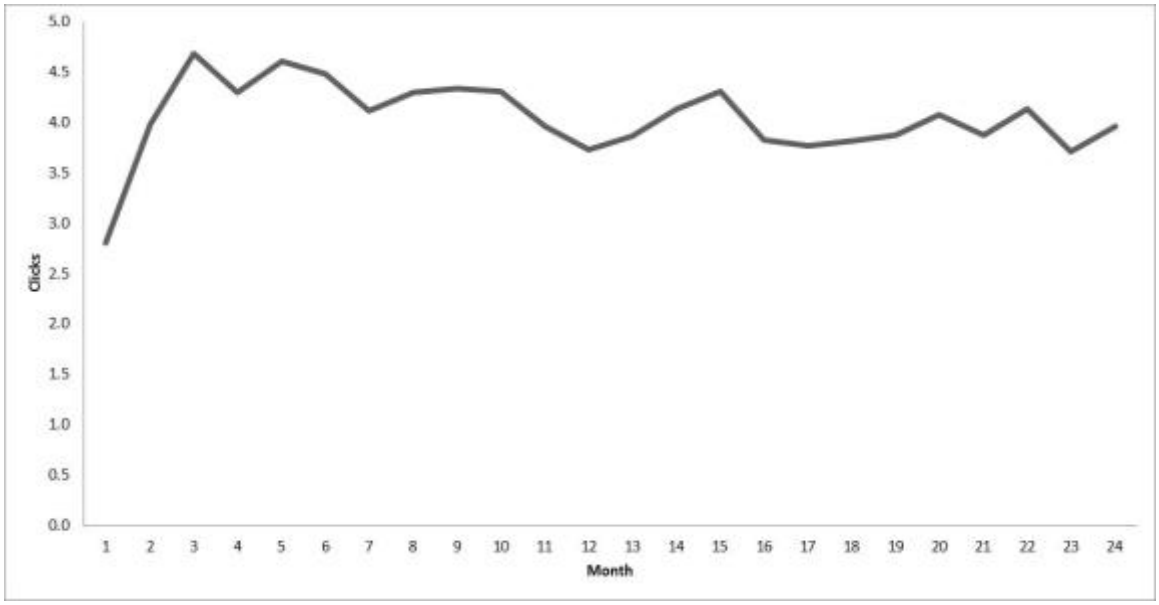

Figure 3 - Average Number of Total Clicks per Active User per Month

Our data included the gender, age, and aggregate system usage of each patient. The system usage was determined by looking at the system use logs that record user's menu clicks with a time stamp together with the name of the menu item accessed, i.e., feature. For example, a patient clicking on Appointments>Upcoming Appointments menu illustrated in Figure 4 is recorded as Appointment Details with a time stamp of the click. In total, our data set included click data on 45 portal features. This click data allows us to investigate activity and utilization patterns among different patient groups at a fine granularity (feature level) as well as at the system login level.

Figure 4 - Patient Portal Appointments Options

Data Preparation

The initial data consisted of 24 distinct files, one per month. This data, generated using raw time-stamp information from individual patient menu clicks (we will refer to

menu clicks as clicks from this point forward), contained the total count of clicks per patient generated monthly, which we term MTCC (monthly total count of clicks). This monthly information was also converted into a more granular format representing the number of unique hour blocks (MTCHC, i.e., monthly total count of hourly clicks based on set times) that patients utilized the patient portal, which can be regarded as distinct *episodes of use*. As an example, if a user had ten total clicks (MTCC) for the *Login* feature in August 2010, the clicks were categorized into distinct hours in which they occurred, so that there could be no more than ten such hourly click counts. At the other extreme, if all ten clicks were generated within the same hour block (e.g. 2010/08/08 11:01 AM to 2010/08/08 11:41 AM), this would yield a value of one for MTCHC in August 2010. Finally, these individual monthly total and hourly counts were then consolidated into an aggregate database using patient subject ID as the unique key.

New users were regularly joining the PHR over the 24-month course of our study. Because of the importance of having a reliable way to measure the patient's portal feature usage during their existence in the system, we considered the average monthly use for each patient over each feature, i.e., the MTCC divided by the total number of months that user was in the system. We refer to this metric as the cumulative use, i.e., average monthly total count of clicks (AMTCC). We did this in similar fashion for the MTCHC data, creating AMTCHC; from now on, we will refer to this metric (AMTCHC) as sessions of use.

Data Organization and Division

As discussed in the previously posed hypotheses, we focus on studying feature usage given patient demographics and time considerations. To prepare for the exploratory data analysis we conducted, we next discuss several convenient ways in which our data was decomposed into its constituent components.

***Selecting Features*:** Out of the 45 distinct features collected in our data set, Figure 5 displays the frequency of the ten most commonly utilized features. Out of these ten, Login and Logout reflect system use at a general level. Therefore, we included Login clicks to understand general utilization levels over time. Lab Tests and Lab Results were the second and third most highly ranked features. These were highly correlated due to the way the portal is designed, with Lab Tests being the more inclusive of the two. Therefore,

we only included Lab Tests data. For similar reasoning, we chose Appointment Review over Appointment Details. We decided not to include Terms and Conditions since our study was focused on features that directly impacted health management. As a result, we selected Login, Appointment Review, Lab Tests, Medical Advice Request (MAR)[3], Messaging, and Result Component Graphing (RCG[4]) for our analysis. These features portray a broad representation of system use across not only our population, but also across previously studied populations as reported in the personal health records utilization literature (Halamka et al., 2008, Ralston et al., 2007).

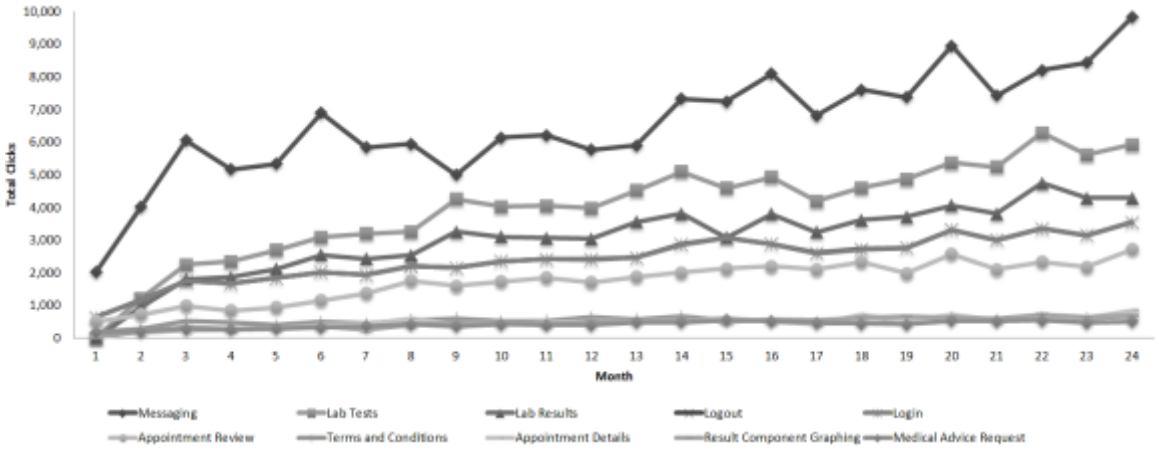

Figure 5 - Number of Total Clicks per Month per Feature for Top Ten Features

Determining Age Groups in Patient Demographics: We formed four distinct age groups 18-35, 36-49, 50-65, and over 65, considering the changes in health management needs due to aging and related preventative care requirements. These age groups are consistent with the literature that investigates health management data (Maguire and Dhar, 2012), and further represent Generation Y, Generation X, Baby Boomers, and Veterans (Glass, 2007). Patients were assigned to a group based on their age when they joined as a portal user. Table 1 shows the convention we use to refer to these age ranges.

[3] Medical Advice Request (MAR) refers to the secure messaging feature of the system. Through this feature portal users can communicate with their provider team.
[4] The Result Component Graphing (RCG) feature provides portal users tools to graph their vital signs and other lab results over time.

Table 1: Naming Convention for Age Ranges in Study

Age Range in Study	Naming Convention	Corresponding Generation
18-35	Gen Y	Generation Y
36-49	Gen X	Generation X
50-65	BB	Baby Boomers
>65	Vets	Veterans

Data Analysis

We plotted histograms for the chosen features across all patients to determine how their utilization patterns were distributed. Each of the resulting plots demonstrated a rather right-skewed distribution with a large number of zero values, corresponding to patients who did not use the feature within a given month. Due to the non-normality of patient utilization patterns, we employed the Mann–Whitney U test in all of our analyses to eliminate the need for distribution assumptions as well as outlier effects.

Level of Analysis: One of the main contributions of our study is the introduction of a time component in our analysis that is not found in other studies in the literature. Specifically, dividing the data into the levels of cumulative use (AMTCC) and sessions of use (AMTCHC) allowed us to investigate possible relationships between these two different representations of the data.

Hypothesis Testing*:* Our hypothesis tests considered the feature, gender, age, and levels of use classifications to determine if patient demographics and time considerations affect feature usage behavior. In particular, we fixed one of the six features and progressively subdivided into demographic and time elements to test our exploratory hypotheses.

We compared gender across cumulative use and sessions of use by running two hypotheses tests for H1. We compared gender in all four age groups across cumulative use and sessions of use to test H2 – totaling eight hypotheses tests. We paired the four age groups (resulting in 6 pairs) across cumulative use and sessions of use, forming 12 hypotheses tests, to test H3. We compared age group pairs (6 pairs in total) for males and females across cumulative use and sessions of use, a total of 24 hypotheses tests, to test H4. In all, there were 276 hypotheses tests (sum of hypotheses (2+8+12+24=46) × 6 features), each of which tested the null hypothesis that the means are not different.

As our data was already stored in Microsoft Excel, the statistical tests were conducted seamlessly through the use of the StatTools Excel add-in, enabling us to maintain efficient handling and manipulation of the data in Excel. In consideration of the moderate number of hypothesis tests we conducted, we required a more stringent significance level of $\alpha = 0.01$ to be observed to reject the null hypothesis for any single comparison.

Results

In this section, we first present the average tables for all hypotheses tested and then in the following subsections, discuss the results relevant to each of the four hypotheses, respectively. Standard deviations are given in parentheses in each of these tables.

Table 2 illustrates the averages for each feature across genders in the overall population. Table 3 presents the averages for each age group across different features. Table 4 and Table 5 present cumulative use and sessions of use of each feature respectively for males and females within an age group.

In what follows, unless otherwise stated, the findings are valid using both cumulative use and sessions of use data.

Table 2 - Cumulative Use (AMTCC) and Sessions of Use (AMTCHC) by Gender

Feature	Cumulative Use		Sessions of Use	
	M n=794	F n=1135	M n=794	F n=1135
Login	3.23 (2.26)	3.55 (3.03)	1.36 (1.08)	1.35 (1.25)
Lab Tests	6.29 (6.50)	6.85 (9.37)	1.58 (1.21)	1.77 (1.75)
Messaging	7.94 (8.07)	8.84 (10.25)	2.92 (2.02)	3.20 (2.61)
RCG	0.77 (1.35)	0.68 (1.40)	0.27 (0.48)	0.31 (0.54)
App. Review	2.37 (2.27)	2.37 (2.76)	1.69 (1.52)	1.94 (1.78)
MAR	0.49 (0.91)	0.57 (1.01)	0.36 (0.46)	0.35 (0.46)

Table 3 - Cumulative Use (AMTCC) and Sessions of Use (AMTCHC) by Age Group

Feature	Cumulative Use				Sessions of Use			
	Gen Y n=226	Gen X n=391	BB n=758	Vets n=570	Gen Y n=226	Gen X n=391	BB n=758	Vets n=570
Login	3.60 (3.56)	3.30 (2.86)	3.29 (2.67)	3.56 (2.46)	3.24 (2.74)	3.01 (2.56)	2.98 (2.34)	3.16 (2.18)
Lab Tests	6.80 (10.40)	6.65 (9.55)	6.18 (6.64)	6.99 (8.39)	1.94 (2.14)	1.68 (1.65)	1.59 (1.39)	1.70 (1.39)
Messaging	6.60 (7.44)	7.84 (8.89)	8.76 (10.64)	9.06 (8.57)	1.74 (1.75)	1.79 (1.79)	1.81 (1.60)	1.92 (1.68)
RCG	0.28 (0.50)	0.77 (1.46)	0.75 (1.20)	0.80 (1.70)	0.18 (0.29)	0.39 (0.54)	0.37 (0.45)	0.37 (0.46)
App. Review	1.98 (2.47)	2.07 (2.20)	2.16 (2.09)	2.95 (3.23)	1.10 (1.02)	1.21 (1.07)	1.30 (1.13)	1.60 (1.34)
MAR	0.54 (0.99)	0.59 (0.97)	0.57 (1.04)	0.44 (0.85)	0.31 (0.53)	0.33 (0.50)	0.31 (0.54)	0.25 (0.48)

Table 4 – Cumulative Use (AMTCC) for Males and Females in Each Age Group

Feature	Gen Y		Gen X		BB		Vets	
	M n=65	F n=161	M n=134	F n=257	M n=328	F n=430	M n=271	F n=299
Login	3.24 (2.92)	3.75 (3.50)	2.76 (1.98)	3.59 (3.20)	3.13 (2.22)	3.41 (2.96)	3.56 (2.23)	3.57 (2.66)
Lab Tests	5.61 (6.62)	7.28 (11.56)	5.28 (6.59)	7.37 (10.72)	5.98 (5.53)	6.34 (7.38)	7.27 (7.34)	6.73 (9.25)
Messaging	5.57 (8.43)	7.02 (6.99)	6.53 (7.61)	8.52 (9.44)	7.76 (8.03)	9.52 (12.21)	9.24 (8.05)	8.89 (9.02)
RCG	0.30 (0.59)	0.27 (0.47)	0.63 (1.47)	0.84 (1.46)	0.79 (1.24)	0.71 (1.17)	0.92 (1.50)	0.69 (1.86)
App. Review	1.99 (2.21)	1.97 (2.58)	2.11 (2.18)	2.05 (2.21)	2.02 (1.94)	2.26 (2.20)	2.96 (2.58)	2.94 (3.73)
MAR	0.53 (0.95)	0.55 (1.00)	0.51 (0.85)	0.63 (1.03)	0.53 (1.07)	0.60 (1.02)	0.41 (0.68)	0.47 (0.98)

Table 5 - Sessions of Use (AMTCHC) for Males and Females in Each Age Group

Feature	Gen Y		Gen X		BB		Vets	
	M n=65	F n=161	M n=134	F n=257	M n=328	F n=430	M n=271	F n=299
Login	2.90 (2.56)	3.37 (2.81)	2.53 (1.73)	3.27 (2.87)	2.85 (2.01)	3.08 (2.55)	3.16 (2.00)	3.16 (2.33)
Lab Tests	1.56 (1.66)	2.09 (2.29)	1.33 (1.07)	1.86 (1.87)	1.51 (1.11)	1.65 (1.57)	1.77 (1.24)	1.65 (1.50)
Messaging	1.62 (1.88)	1.79 (1.69)	1.40 (1.39)	1.99 (1.94)	1.61 (1.45)	1.96 (1.69)	1.91 (1.54)	1.93 (1.80)
RCG	0.16 (0.30)	0.19 (0.29)	0.31 (0.44)	0.43 (0.59)	0.37 (0.44)	0.37 (0.46)	0.43 (0.52)	0.32 (0.40)
App. Review	1.13 (1.09)	1.09 (1.00)	1.22 (1.05)	1.21 (1.08)	1.22 (1.00)	1.36 (1.22)	1.62 (1.15)	1.57 (1.50)
MAR	0.32 (0.54)	0.31 (0.52)	0.27 (0.43)	0.36 (0.53)	0.28 (0.55)	0.33 (0.53)	0.24 (0.37)	0.27 (0.57)

H1. There is no difference in system feature utilization at the level of *cumulative use* or *sessions of use* between genders.

Although the PHR literature reports females are more frequent users of patient portals (Carrell and Ralston, 2006), as Table 6 illustrates, we did not observe any significant difference between genders for Login, Lab Tests, RCG, Appointment Review, and Medical Advice Request. For Messaging, we did not observe any significant difference between genders when we analyzed cumulative use data. However, analysis of sessions of use data revealed that females do use this feature more than males; this was the only statistically significant difference when comparing genders.

Null Hypothesis H_0	Login	Lab	Mess.	RCG	App.	MAR
There is no difference in cumulative use (AMTCC) between males and females						
There is no difference in sessions of use (AMTCHC) between males and females			Reject			

Table 6 - Null Hypothesis for H1 (empty cell means Do Not Reject)

H2. There is no difference in system feature utilization at the level of cumulative use or sessions of use between genders within a particular age group.

This hypothesis expands on H1 by breaking down males and females, respectively, into the four defined age groups. The results of hypothesis testing are

presented in Table 7. When we look at Login by gender in different age groups, only for Gen X is there a statistically significant difference: female users in this age group log into the portal more than male users. In addition, Gen X female patients utilize Lab Tests and Messaging more than the Gen X males. We also observed that Gen X females use RCG more than Gen X males, though this is significant only using cumulative use data. This indicates that when we compare sessions of use represented by AMTCHC, we do not observe any gender difference in Gen X utilization of RCG. The only other significant difference between genders within the same age group was identified in RCG utilization among Vets, where males utilized this feature more than females. We cover this in further detail in the Discussion section.

Table 7 - Null Hypothesis for H2 (empty cell means Failed to Reject)

Null Hypothesis H_0	Login	Lab	Mess.	RCG	App.	MAR
There is no difference in cumulative use (AMTCC) between:						
males and females of Gen Y						
males and females of Gen X	Reject	Reject	Reject	Reject		
males and females of BB						
males and females of Vets				Reject		
There is no difference in sessions of use (AMTCHC) between:						
males and females of Gen Y						
males and females of Gen X	Reject	Reject	Reject			
males and females of BB			Reject			
males and females of Vets				Reject		

H3. There is no difference in system feature utilization at the level of cumulative use or sessions of use between age groups.

When we compared system logins of different age group pairs, we found that Vets have higher Logins compared to Gen X and BB. No other significant differences were observed at the general system use level. On the other hand, our analysis of the five features produced a variety of significant results as illustrated in Table 8.

For Appointment Review, Vets utilized this feature more than all other age groups. BB patients also utilized this feature more than Gen Y. For Messaging, Vets utilized this feature more than Gen Y as well as Gen X for cumulative use data, however no significant difference was observed with BB patients. BB patients also used this feature more as compared to Gen Y, the youngest group, using cumulative use data. We

did not find any significant differences using sessions of use data. For Result Component Graphing (RCG), Gen Y uses this feature significantly less than all older age groups. We did not observe any differences among age groups for Lab Tests and Medical Advice Request features.

Null Hypothesis H_0	Login	Lab	Mess.	RCG	App.	MAR
There is no difference in cumulative use (AMTCC) between:						
Gen Y and Gen X				Reject		
Gen Y and BB			Reject	Reject	Reject	
Gen Y and Vets			Reject	Reject	Reject	
Gen X and BB						
Gen X and Vets	Reject		Reject		Reject	
BB and Vets	Reject				Reject	
There is no difference in sessions of use (AMTCHC) between:						
Gen Y and Gen X				Reject		
Gen Y and BB				Reject	Reject	
Gen Y and Vets				Reject	Reject	
Gen X and BB						
Gen X and Vets	Reject				Reject	
BB and Vets	Reject				Reject	

Table 8 - Null Hypothesis for H3 (empty cell means Do Not Reject)

The variation in these results could indicate that, although older patients tend to use the system more, there are certain functions particular age groups tend to utilize more or less depending on the health management needs of a specific age group. Older patients tend to have more health issues, appointments, and information to manage (LeRouge et al., 2014); and hence utilize features that support these needs more, such as Appointment Review and Messaging. On the other hand, utilization of features such as Lab Tests and Medical Advise Request may be useful for both older and younger patients. We should also emphasize that the difference in Messaging was only significant using cumulative use data, and address this in greater detail in the Discussion section.

H4. There is no difference in system feature utilization at the level of cumulative use or sessions of use between age groups within a particular gender.

Table 9 illustrates that among males, age had some influence on Logins. An analysis of both data levels revealed that males who are Vets logged in more than their Gen X and BB counterparts, respectively. No differences were found in other age group

comparisons for males in Logins. Interestingly, age group comparisons for female patients did not reveal any significant difference in Logins. This may indicate that general system utilization is more uniform among age groups for female patients.

For Appointment Review, both male and female Vets seem to utilize this feature more than their counterparts who are in the youngest two age groups (i.e., Gen Y and Gen X). We also identified two additional differences, one in the male population and the other in the female population. Male Vets utilize this feature more than male BB patients, which was not the case for females. On the other hand, female BB patients utilized this feature more than Gen Y females; again, this difference was not observed in the other gender. This illustrates that within a particular gender, there are differences in utilization of certain features.

For Lab Tests, we did not observe any difference in utilization of this feature among female patients. Among males, Vets utilized this feature more than BB and Gen X patients. In addition, we observed a curious difference in the utilization of this feature among males in the youngest (Gen Y) and the oldest (Vets) age groups. Male Vets use this feature more than Gen Y males, but only when we look at the cumulative use data; there was no such difference in sessions of use data. This may be due to more efficient use of this feature by younger males, which we address in greater detail in the 'Discussion' section.

For Messaging, we once again observed that male Vets utilize this feature more than BB and Gen X males. In addition, both male and female Vets use this feature significantly more than their Gen Y counterparts, but only for cumulative use data. The same phenomenon was observed among BB patients as compared to Gen Y. This again points to the efficient use of certain system features among the youngest patients.

For RCG, the two oldest age groups for both genders, Vets and BB, utilized this feature more than their counter-parts in Gen Y. We also observed that Gen X female patients utilize this feature more than Gen Y females. For females, we found that Gen Y uses this feature less than all other age groups. However, among male patients we observed differences between older age groups. Male BB and Vets patients used this feature more than Gen X, but the latter comparison was significant only for cumulative use data.

Table 9 - Null Hypothesis for H4 (empty cell means Do Not Reject)

Null Hypothesis H_0	Login	Lab	Mess.	RCG	App.	MAR
There is no difference in cumulative use (AMTCC) between:						
Females of Gen Y and Gen X				Reject		
Females of Gen Y and BB			Reject	Reject	Reject	
Females of Gen Y and Vets			Reject	Reject	Reject	
Females of Gen X and BB						
Females of Gen X and Vets					Reject	
Females of BB and Vets						
Males of Gen Y and Gen X						
Males of Gen Y and BB			Reject	Reject		
Males of Gen Y and Vets		Reject	Reject	Reject	Reject	
Males of Gen X and BB				Reject		
Males of Gen X and Vets	Reject	Reject	Reject	Reject	Reject	
Males of BB and Vets	Reject	Reject	Reject		Reject	
There is no difference in sessions of use (AMTCHC) between:						
Females of Gen Y and Gen X				Reject		
Females of Gen Y and BB				Reject	Reject	
Females of Gen Y and Vets				Reject	Reject	
Females of Gen X and BB						
Females of Gen X and Vets					Reject	
Females of BB and Vets						
Males of Gen Y and Gen X						
Males of Gen Y and BB				Reject		
Males of Gen Y and Vets				Reject	Reject	
Males of Gen X and BB						
Males of Gen X and Vets	Reject	Reject	Reject	Reject	Reject	
Males of BB and Vets	Reject	Reject	Reject		Reject	

Finally, we did not see any significant difference in utilization of MAR feature when varying genders or age group pairs using cumulative use or sessions of use data. In general, we observed fewer differences in utilization among female users when we categorized by age as com-pared with male users. Age seemed to have a greater effect on how males choose to utilize different features of the system.

Discussion

Recall that we only report on findings that were statistically significant at the $\alpha = 0.01$ level using the Mann– Whitney U test. A summary of our significant results for both data levels is presented in Table 10. We group our findings under two main themes: (1) effects

of age and gender on system use, by feature, and (2) effects of age and gender on efficiency of use, by feature.

Effects of age and gender on use vary by system feature

Overall, Vets and Gen Y have the highest count for Login. While high utilization is to be expected with younger patients, high utilization among seniors is not very common. According to a recent Pew Research study, senior Americans still lag behind in technology adoption com-pared with younger Americans (Smith, 2014). Moreover, adults 65 and above are reported to be less likely to rate electronic access to PHR as important compared with younger age group (Wen et al, 2010). A review paper on the adoption of consumer health information technologies also points out that age and gender are the top two studied variables in this domain; however, there is no consensus on their effects on use as the studies either present conflicting results or report no effect (Or & Karsh, 2009). Our results indicate that analyzing gender and age effects requires a more detailed approach. When it comes to issues with which they are concerned, in this case personal health, Vets may be more willing to use the system as compared with BB and Gen X. Moreover, of the two genders, males seem to drive the higher utilization for the Vets, whereas female utilization is more stable across the age group pairs.

We also see differences in utilization of features among different genders and age groups. Within gender, there is a clear tendency for older male age groups to exhibit greater utilization for each of the features (except for MAR) at the level of cumulative use as well as sessions of use (see Figure 6). However, no such trend in utilization exists at the level of cumulative use or sessions of use among females for each of the features, indeed, only relatively small variations are evident. This may be another indication that males become increasingly interested in their health as they age, especially in light of the general trend that male utilization is significantly lower than female utilization across multiple features at the level of cumulative use as well as sessions of use.

Table 10 – Summary of Significant Results and *p*-values

H	Feature	Age Grp	Gender	Use	Age Grp	Gender	P_{AMTCC}	P_{AMTCHC}
1	Messaging	All	F	more than	All	M	0.0465	0.0016
2	Lab Tests	Gen X	F	more than	Gen X	M	0.0037	0.0005
2	Login	Gen X	F	more than	Gen X	M	0.0060	0.0097
2	Messaging	Gen X	F	more than	Gen X	M	0.0099	0.0006
2	RCG	Gen X	F	more than	Gen X	M	0.0088	0.0181
2	RCG	Vets	M	more than	Vets	F	0.0057	0.0070
2	Messaging	BB	F	more than	BB	M	0.0189	0.0019
3	Login	Vets	All	more than	Gen X	All	0.0006	0.0065
3	Login	Vets	All	more than	BB	All	0.0005	0.0077
3	App. Review	Vets	All	more than	BB	All	< 0.0001	< 0.0001
3	App. Review	BB	All	more than	Gen Y	All	0.0034	0.0025
3	App. Review	Vets	All	more than	Gen Y	All	< 0.0001	< 0.0001
3	App. Review	Vets	All	more than	Gen X	All	< 0.0001	< 0.0001
3	Messaging	BB	All	more than	Gen Y	All	0.0004	0.1483
3	Messaging	Vets	All	more than	Gen Y	All	< 0.0001	0.0176
3	Messaging	Vets	All	more than	Gen X	All	0.0010	0.0223
3	RCG	Gen X	All	more than	Gen Y	All	< 0.0001	< 0.0001
3	RCG	BB	All	more than	Gen Y	All	< 0.0001	< 0.0001
3	RCG	Vets	All	more than	Gen Y	All	< 0.0001	< 0.0001
4	App. Review	BB	F	more than	Gen Y	F	0.0024	0.0031
4	App. Review	Vets	F	more than	Gen Y	F	< 0.0001	< 0.0001
4	App. Review	Vets	F	more than	Gen X	F	0.0011	0.0003
4	Messaging	BB	F	more than	Gen Y	F	0.0055	0.1199
4	Messaging	Vets	F	more than	Gen Y	F	0.0097	0.2415
4	RCG	Gen X	F	more than	Gen Y	F	< 0.0001	< 0.0001
4	RCG	BB	F	more than	Gen Y	F	< 0.0001	< 0.0001
4	RCG	Vets	F	more than	Gen Y	F	< 0.0001	< 0.0001
4	App. Review	Vets	M	more than	BB	M	< 0.0001	< 0.0001
4	App. Review	Vets	M	more than	Gen Y	M	0.0005	0.0002
4	App. Review	Vets	M	more than	Gen X	M	< 0.0001	< 0.0001
4	Lab Tests	Vets	M	more than	BB	M	0.0074	0.0014
4	Lab Tests	Vets	M	more than	Gen Y	M	0.0035	0.0141
4	Lab Tests	Vets	M	more than	Gen X	M	< 0.0001	< 0.0001
4	Login	Vets	M	more than	BB	M	0.0013	0.0086
4	Login	Vets	M	more than	Gen X	M	< 0.0001	0.0001
4	Messaging	Vets	M	more than	BB	M	0.0043	0.0039
4	Messaging	BB	M	more than	Gen Y	M	0.0065	0.3395
4	Messaging	Vets	M	more than	Gen Y	M	< 0.0001	0.0129
4	Messaging	Vets	M	more than	Gen X	M	< 0.0001	< 0.0001
4	RCG	BB	M	more than	Gen X	M	0.0017	0.0156
4	RCG	BB	M	more than	Gen Y	M	< 0.0001	< 0.0001
4	RCG	Vets	M	more than	Gen Y	M	< 0.0001	< 0.0001
4	RCG	Vets	M	more than	Gen X	M	< 0.0001	0.0005

Although we did not see a significant difference in RCG utilization between males and females over the entire population, when dividing into separate age groups we identified that male Vets are utilizing this feature significantly more than females at the level of cumulative use and sessions of use. This is intriguing because it is the only instance where males in an age group have a significantly higher utilization for a particular feature than their female counterparts. Given that the RCG feature is simply a graphical representation of trend data (such as blood pressure, or weight over time) that is already presented in other sections of the portal in list format, the observed variation in utilization may point to differences in data visualization preferences of males and females in this age group.

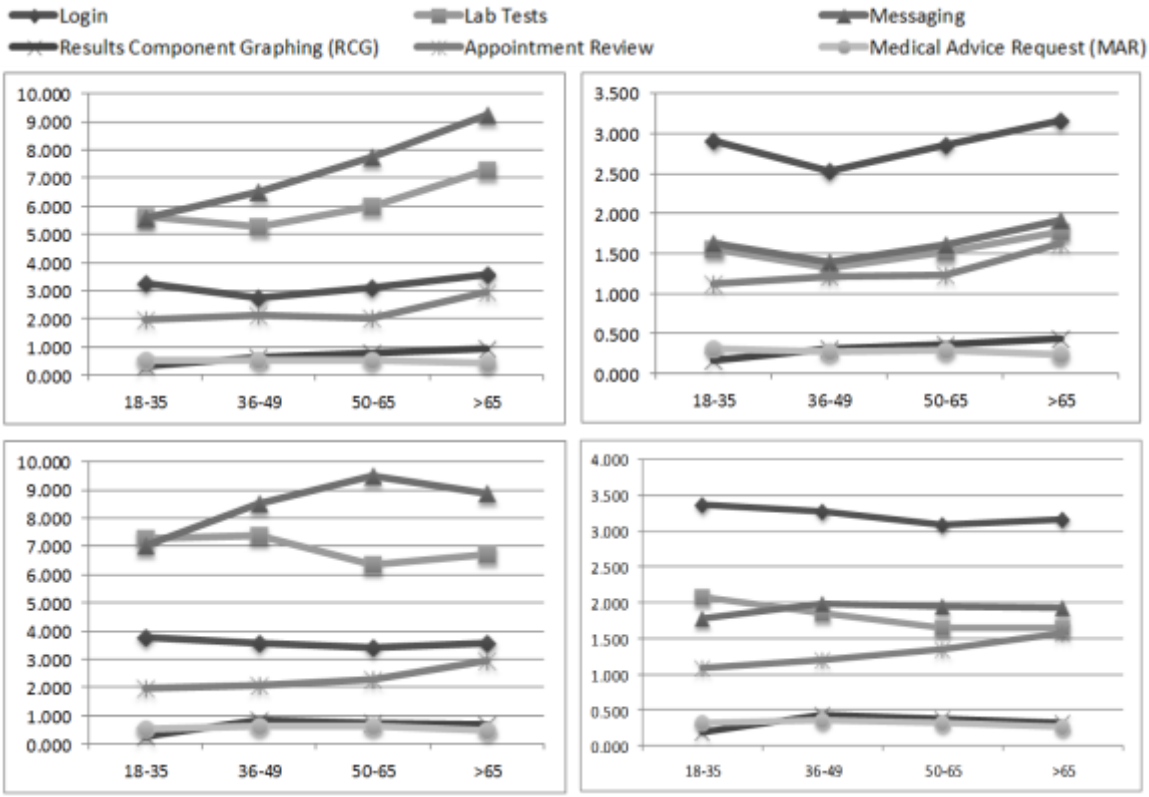

Figure 6 - Cumulative Use (AMTCC on left) and Sessions of Use (AMTCHC on right) by male (top) and female (bottom) age groups for various features

We also observed that the highest utilization of the Appointment Review feature is by Vets. This may simply be because of the increased number of appointments as a patient ages and develops more medical conditions, thus requiring more frequent

preventative care visits. For males, our observations indicate that the Vets' utilization is significantly higher than other age groups, whereas for females, both the Vets and BB patients behave similarly and utilize this feature more than Gen Y.

Efficiency of Use varies across age, gender and feature. We observed some additional differences in use patterns across the dimensions of frequency and repetition; for example, the cumulative clicks generated by an individual may be high but these clicks may not spread out into many different sessions of use, whereas another user may be generating fewer clicks but these clicks may be spread across many sessions. We call this phenomenon efficiency of use. We observed this phenomenon when results varied for cumulative use, compared to sessions of use. To illustrate, suppose a patient segment (e.g., males) uses a feature significantly more as measured by cumulative use than a different patient segment (e.g., females), but not for sessions of use. In this case, the average number of monthly clicks for males is greater than females, but the average number of monthly sessions is not. Across the group, males click more on the same feature than females within the set hourly timeframe; females may thus be able to get the information they require with fewer clicks, exhibiting greater efficiency of use.

We observed this behavior in multiple settings. For one, male Vets use the Lab Tests and Messaging features more than Gen Y males at the level of cumulative use, but not sessions of use. Additionally, this behavior was observed in Messaging, where older patients had significant differences with younger groups at the level of cumulative use but not sessions of use data. This may point to more efficient utilization by younger age groups. The older groups are generating significantly more total clicks but not significantly more sessions of use for these features. This implies that older age groups generated additional clicks in the same session, which may be due to their lack of familiarity with electronic messaging applications. Younger generations may be more effective in communicating electronically, resulting in fewer total clicks.

On a similar but slightly different note, although the Messaging clicks that male and female patients generate are not significantly different at the cumulative use level for both the entire population (as well as for just the BB patients), the observed differences in sessions of use data indicate that females tend to spread out their clicks in different

sessions of use as compared with males, and so generate fewer clicks per session. Another interpretation is that females are more efficient in using this feature.

Limitations and Future Work

The data that was collected provided us with access to monthly total count of clicks, which we referred to as cumulative use, as well as the number of different hourly periods these clicks were spread across, which we referred to as sessions of use. However, we did not have access to detailed click information, and this was a limitation of our study. More complete click information could have led to better and more accurate determinations of sessions of use. For example, sessions could be identified more accurately by looking at Login as the beginning of a session and Logout as the end of a session. However, even the limited measures of sessions by hourly blocks provided insights into understanding system utilization using click data. Future studies would benefit from using raw click data, something we did not have access to in this study. With raw click data, analysis focusing on determining sessions of use in a more refined manner (i.e. Login-Logout as data borders) and on identifying utilization patterns could provide more insights into patient portal use. In addition, future studies using click data can be coupled with more information about the patients such as their marital status or their care giver status, or with qualitative information from patient focus groups to better interpret the reasons behind certain use patterns.

Though we did not do so in this study, it is also possible to investigate the degree to which patient utilization varies following the initial registration in the system. Such variability can have different meanings depending on the time component – varying on the monthly total count, as compared to the distinct hour count (a proxy for distinct sessions of use). While some fluctuation in monthly usage might be expected due to seasonal effects, etc., a large amount of fluctuation may be revealing. On the other hand, consistent utilization over a patient's entire data history, with little variance, may indicate the patient has embraced the system, reflecting portal adoption.

The way we determined different age groups could also be a potential limitation. We defined these groups based on transitions related to health management that naturally occur as a result of the aging process, as well as on the studies that focus on generation

differences. However, in future studies a more granular set of age groups could also be determined to better understand the effects of age on utilization – though such a design should be constructed with care given the potentially large number of hypothesis tests.

Future studies may also focus on provider effects on patient portal utilization. It is important to understand how and why provider attitudes towards patient portals might affect patients' utilization of the system. In systems like patient portals, patients have more autonomy in terms of how they choose to handle their personal health information and communicate with their providers. Focusing on supporting patients in their use of the system may lead to higher adoption and utilization. Future studies should also focus on identifying the reason behind different levels of use across system features.

Another extension of our work relates to engaging newly registered portal patients with the most useful presentation of information. There is a time-sensitive component to portal adoption as a result of meaningful use criteria. Customizing portal design for new users based on the patterns of use observed in the system use logs may result in increased adoption rates.

Click data analysis have been used in the other fields such as Marketing and Operations (Bucklin and Sismeiro, 2009, Huang and Van Mieghem, 2014, Kou and Lou, 2012, Olbrich and Holsing, 2011, Wei et al., 2012) where various techniques to extract information from the click data are utilized. In this study, pairwise comparison was used to determine differences within our population. Future studies can incorporate different click data analysis techniques to gain more insights from this valuable data set.

Conclusions

This paper focused on using different levels of system use data (click data stored in system logs) for analysis of patient portal utilization. We interpreted click information by analyzing both the total number of clicks, cumulative use, and the total number of distinct hours these clicks represent, sessions of use. We looked at age and gender differences in patient portal utilization using this approach. We not only analyzed utilization at the general system level but also drilled down to the utilization of specific features. This led to an improved understanding of differences in system utilization among patients.

It is important to consider that users of these systems will be from various generations with different preferences and utilization patterns. A granular understanding of system utilization among different users can help healthcare organizations better support their patient portal users and train their personnel for potential patterns of use. By identifying which age and gender groups are more likely to utilize certain features effectively, healthcare organizations can design better marketing materials and help physicians communicate more effectively with their patients in the exam room or in their paper-based communications. Essentially, if practitioners know which features are being used and their use frequency among their patient panels, they can more effectively communicate with the patients, either by using the portal more – for example because they now know that the senior population can effectively use/respond to electronic portal messages/info – or use alternative communication methods (letter, phone call, office visit) when they know certain features are not well utilized by their patient population.

The analysis of patient portal utilization can also help health systems become aware of the potential limitations or underutilized areas of the portal for certain age groups and genders. This can lead to exploration of reasons for underutilization and improvements in the system or the design of the interface. For example, based on a patient's particular demographics, it may be possible to predict desirable features a priori and display them more prominently in the portal. System developers can also learn from these patterns of use and design better system interfaces that address the needs of all generations. In summary, finding different ways of analyzing the system logs can help healthcare organizations materialize the benefits of patient portals. Our study demonstrated how click data could be utilized to create different levels of analysis that can generate new insights.

The purpose of this study was to explore the potential of click-stream data from patient portals for identifying patient use patterns and variations. Although we provide some explanation throughout the paper for the reasoning behind the differences observed in patient portal use, the limitations presented in the previous section and the exploratory nature our study prevent us from drawing stronger conclusions. The accuracy and generalizability of our claims should be assessed by further research in this domain.

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