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Towards actionable knowledge: A systematic analysis of mobile patient portal use

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Toward Actionable Knowledge: A Systematic Analysis of Mobile Patient Portal Use

Cherie Noteboom and Mohammad Abdel-Rahman (Al-Ramahi)

1 Introduction

The American elderly population aged 65 and older is expected to continue to grow rapidly. This population segment is expected to reach 89 million by 2015 (Dall et al. 2013). The population reports increasing health complexities, due to increases in chronic disease, and many report suffering from multiple chronic disease. Estimates predict that by 2030, there will be an additional 27 million Americans with hypertension, eight million with coronary heart disease, and three million with heart failure (Heide 1). Cancer cases are expected to increase to 27 million (Suzman and Beard 2011). Alzheimer's is estimated to grow to 7.1 million, a 40% increase, by 2025 (Alzheimer's Association 2013).

Healthcare in America costs 2.5 trillion a year and is expected to grow to 4.5 trillion in six years (Clifton 2012). According to the Agency for Healthcare Quality and Research, automation can improve the quality and safety of care delivered by healthcare facilities by enabling collaboration among physicians, medical personnel and patients (Clifton 2012). Understanding the healthcare context is key to understanding the integration of information systems (IS) into the fabric of their organizations. According to Fichman, Kohli, and Krishnan (2011):

> *at the most general level, a striking feature of healthcare industry is the level of diversity that characterizes patients (e.g., physical traits and medical history), professional disciplines*

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> *(e.g., doctors, nurses, administrators and insurers), treatment options, healthcare delivery processes and interests of various stakeholder groups. (p. 419)*

Patient-centered care is seen to be a natural progression toward greater efficiency and effectiveness in healthcare provision. This form of care is one in which a patient actively participates in his or her care, delivery of care takes place from a patient's point of view, there is greater communication with the patient, and therapy is tailored to the needs of the patient (Murphy 2011; Sacristán 2013; Stewart et al. 2000). The implementation of health information technology (HIT) appears to have enabled greater patient-centered care through better access to patient data, shorter recovery through targeted care, and lower cost through fewer tests (Blumenthal and Tavenner 2010; Cliff 2012; Cohen et al. 2010; Fichman et al. 2011).

Patient-centered care implies a paradigm shift in the relationship between doctors and patients, but also requires the development of self-management practices (Sacristán 2013). Kane and Labianca (2011, p. 510) note that, "if patients fail to manage their chronic diseases adequately, escalating conditions can become extremely expensive to treat and can significantly compromise the patient's quality of life." In order to help patients self-manage their diseases, information is made available from HIT products, such as home health devices and patient portals. Patient health records (PHR) technology, often known as patient portal, provides patients with online access to their health records, which in turn enables better disease management through tracking of comprehensive health indicators and lower the cost of care (Cliff 2012; Cohen et al. 2010). Through the potential to provide continuity of service and better care, and the potential to change the physician-patient relationship and enable chronic disease self-management, patient portals are positioned as a central component of patient engagement (McAlearney et al. 2016).

Healthcare organizations in the United States are investing in information technology (IT) to reduce the associated cost of services and improve the quality of patient care in a move toward population health initiatives. IT systems in healthcare organizations must meet requirements, as they positively impact patients. Many of these initiatives focus on education and the engagement of the patient population. Internet of Things (IoT)-supported devices and applications, which continue to experience great growth, are considered a key IT strategy to engage and educate the healthcare population (Allan and Wang 2017; Sacristán 2013).

Healthcare continues to integrate IT solutions to transform the methods of patient interaction to support patient engagement and education. These solutions are transforming how patients participate in their individual care. Seventy-eight percent of healthcare customers either wear or are willing to utilize wearable technology solutions to track their lifestyle choices and vital signs. Mobile medical technology is advocated by 75.5% of physicians who feel that the technology simplifies access and is one of the greatest benefits of mobile medical technology. Nearly half of hospitals provide applications (apps) for patient education and engagement; 58% of hospitals have patient portal solutions (Stewart et al. 2000). The number of health apps exceeds 165,000 (Microsoft n.d.).

Previous technology research (e.g., Qureshi and Keen 2005; Qureshi et al. 2005; Qureshi and Noteboom 2006) has investigated collaboration effects and provides insight to inform the patient portal research in the areas of collaboration, coordination, communication, and adaptation. In addition, the adaptation insights at the work, social, and technology levels inform this research. However, up to now, very few efforts have been made to extract knowledge from online user reviews from actual use of mobile patient portals to help understand patients' concerns that deter effective use of these health technology. Therefore, this research answers the call for the development of patient-oriented research by investigating the key challenges relating to the use of mobile patient portals (i.e., determining the gaps in the design of patient portals) via extracting insights from negative users' reviews of patient portal mobile apps. Such insights can improve the partnership and collaboration between patients and healthcare providers.

The advances of Web 2.0 technologies have enabled consumers to easily and freely exchange opinions on products and services on an unprecedented scale (volume) and in real time (velocity). Online user review systems provide us with one of the most powerful channels for extracting user feedback that can help enhance patient portals design. In the e-commerce domain, user reviews have long been widely recognized as a crucial factor that influences product sales (e.g., Chevalier and Mayzlin 2006) and shapes consumers' purchase intention (e.g., Yang et al. 2016). In the domain of patient portal systems, analyzing users' reviews has the potential to greatly inform developers of patients' preferences and how they engage with health portals, and provide opportunities for further enhancing their efficacy.

In this study, we systematically analyze users' reviews to identify design gaps from the actual use of mobile patient portal. The question investigated in this paper is: What are the gaps in mobile patient portal service to enable patient-centered care? To answer this question, we use an implementation of EPIC's mychart as an instance of mobile patient portal and discover design gaps based on a systematic analysis of users' negative reviews. Instead of manually analyzing the data, which is time-consuming, we utilize a text-mining technique, specifically topic modeling, to analyze the contents of user reviews and identify design gaps for mobile patient portal systems. The key contribution of this research is in discovering the gaps that may exist in current mobile patient portal solutions and identifying the opportunities for mobile patient portal enhancement to achieve improved patient-centered care.

2 Related Work and Background

2.1 Patient-Centered Care

Effective patient-centered care centers on the identification of the best intervention for every individual patient using personalized medicine and tailored therapeutics (Sacristán 2013). To provide patient-centered care, physicians will have to collabo-

rate. Collaboration is a purposeful joint action through the construction of relevant meanings that are shared among members. Collaboration is needed to (1) determine what action is required and relevant, (2) identify knowledge to carry out a required action, and (3) demand for action. To support collaboration, it is necessary to have a media with which to communicate and a social network or "community of minds."

In this regard, patient portals have the potential to better inform and engage patients in their care. Patient portals, now commonly used in ambulatory settings, leverage integration with electronic health record (EHR) efforts to inform and engage patients. Healthcare providers feel the information provided by the portal helps to facilitate patient engagement in care and identification of errors (O'Leary et al. 2016).

2.2 Patient Health Records (Patient Portal)

With the exponential growth of the communications technologies that allow us to potentially reach more individuals regardless of their locations, new types of health intervention have emerged. Smartphone or mobile-based patient portals can enhance patients' engagement at a very low cost. Due to the promising influence of these smartphone-based technologies in supporting healthy lifestyle and self-care practices, researchers have been inspired to explore the impact and use of mobile applications. For example, the fact that women widely used mobile apps for health information during pregnancy, but reported apps as unavailable or invaluable postpartum, highlights the need for the development of more mobile apps with postpartum content (Guerra-Reyes et al. 2016). With this respect, Zhang, Ho, Cassin, Hawa, and Sockalingam's (2015) study is one of the first few studies to describe the methodology of developing an online and smartphone compatible cognitive behavioral therapy intervention program for bariatric surgery patients.

While the results of HIT use by providers are mixed, it appears that motivated patients can achieve significant improvements in their health outcomes when they use mobile applications (García-Gómez et al. 2014). There are currently over 3000 mobile applications available through Google Play Store and Apple Store to support lifestyle changes such as fitness, calorie counter, and body mass index calculators, some of which are used to control diabetes (García-Gómez et al. 2014; Qureshi et al. 2015).

Little research, however, has been done to connect the growing mobile application use by patients to accessing their healthcare data. From a public health perspective, patient-centered care requires "a partnership among practitioners, patients, and their families (when appropriate) to ensure that decisions respect patient's wants, needs, and preferences and that patients have the education and support they need to make decisions and participate in their own care" (IOM

2001, p. 7). Robinson, Callister, Berry, and Dearing (2008) also offer an economic view of the patient as the informed consumer who makes decisions based on cost and quality of care. They also identify care from a patient's perspective to include "respect, courtesy, competence, efficiency, patient involvement in decisions, time for care, availability/accessibility, information, exploring patient's needs, and communication" (Robinson et al. 2008, p. 602). To address these views, patient health portals will need to be customized for patient-centered care.

The focus of previous studies included providing access to the patient record and information on the care team through a mobile phone app (e.g., Pfeifer Vardoulakis et al. 2012), a tablet computer app to view care team profiles and hospital medication records, and a tablet app with the plan of care, diet and safety information (Dykes et al. 2012). Providing patients real-time access to health information has been demonstrated as a positive force for change in the way care is provided (McAlearney et al. 2016). In this regard, Lu et al. (2017) develop an app to inspect controlled substances in patient care units. Using a web-enabled smartphone, pharmacist inspection can be performed on site and the inspection results can be directly recorded into the HIS through the Internet, so human error of data translation can be minimized and the work efficiency and data processing can be improved.

While previous studies reported positive findings, including patient reports of enhanced engagement in the care process and satisfaction with care, none included *patient-centered functionality*, such as the ability to send messages to the care team, allowing patients to input information or record notes—elements that have been demonstrated to further enhance patients' engagement (McAlearney et al. 2016). This is especially true with the proliferation of wearable devices, where data about an individual's health state can be collected by real-time sampling and analysis of a few parameters using noninvasive, inexpensive, and portable devices (Pierleoni et al. 2014). With this respect, Neubeck et al. (2016) adopted a collaborative user-centered design process to develop a patient-centered care tool. O'Leary et al. (2016) concluded that optimizing a hospital-based patient portal will require attention to type, timing and format of information provided, as well as the impact on patient-provider communication and workflow. Patients can identify areas of improvement that could enhance the design of portals. For example, patients suggested inclusion of a test result feature (O'Leary et al. 2016). Therefore, further research is needed to work in concert with patients to explore patient-centered functionalities that help develop a patient-centric portal to increase patients' engagement in their care.

Leveraging user feedback from the actual use of mobile patient portal, this research contributes to an understanding of how the technology architecture can enable patients to interact with patient portal functionality, which is technological adaptation, to work (work adaptation) together with their physicians and care providers (social adaptation) using the content available to them and using the collaboration media to provide patient-centered care.

2.3 The Impacts of User-Generated Content

Several researchers in the areas of social media and e-commerce have studied the effects of user-generated content, such as online users' reviews and rating systems, on product sales and consumers' purchase intention. The findings of the existing research have demonstrated that analyzing and measuring these electronic word-of-mouth (eWOM) messages is quite valuable in product design, sales prediction, marketing strategy, and other decision-making tasks (e.g., Al-Ramahi et al. 2015; Phillips et al. 2016; Yu et al. 2013). In this regard, Guo et al. (2017) adopted latent Dirichlet allocation (LDA) as topic modeling technique to discover key dimensions from online user reviews for hotels located in 16 countries.

Recently, few researchers have been attracted to explore the impact of user-generated content in healthcare domain. For example, Jung et al. (2015) proposed a text mining approach to identify hospital service quality factors and overtime trends automatically from user-generated content from online health communities. Xu et al. (2016) examined the impact of online information on patient choice of outpatient care doctors. Al-Ramahi et al. (2016, 2017) use topic modeling, LDA algorithm, to discover design principles for Health Behavioral Change Support Systems (HBCSSs) from online user reviews of mobile diabetes applications. However, to the best of our knowledge, no research to date has looked at online users' reviews in the context of mobile patient portals. User reviews implicitly communicate satisfaction/dissatisfaction based on actual usage experience and may provide a good opportunity for extracting design dimensions that can strongly influence users' satisfaction and then informing the design of these systems.

3 Method

This section describes the methodology used to investigate: What are the gaps in mobile patient portal service to enable patient-centered care? Figure 1 shows the framework of the text mining-based method, which Al-Ramahi et al. (2017) adopted. We propose to use an unsupervised topic model, LDA, to extract latent dimensions (i.e., design gaps) from user-generated data. Below, we first discuss the data collection and preparation process. We then explain the topic modeling technique used to extract design gaps from online low ratings users' reviews.

3.1 Data Collection and Preparation

In this study, our target population is mobile patient portal users. The patient portal selected as empirical setting of this research is EPIC's mychart. We selected this patient portal for study as EPIC is replacing other vendors in the EHR market

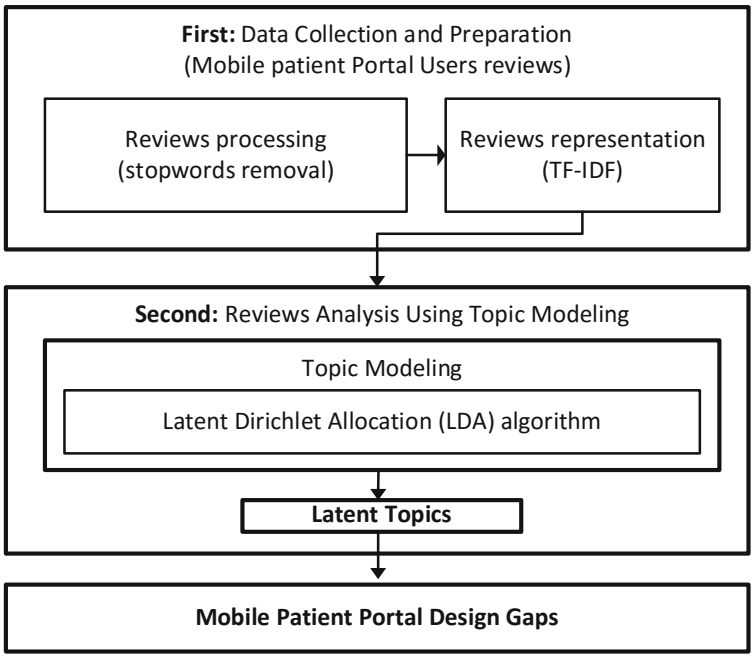

Fig. 1 Architecture of our text mining-based method (Al-Ramahi et al. 2017)

and is beginning to establish a single vendor landscape. Reportedly, EPIC has at least partial health information for over 51% of the U.S. population (Koppel and Lehmann 2014). MyChart mobile app is available for Apple and Android devices. The data were collected from Apple iTunes store, where the online reviews posted by the users were gathered using the Apple store API. We developed a web crawler to automatically collect data. Through this process, we obtained our dataset consisting of 500 reviews. Since the main objective of this research is to identify design gaps of mobile patient portal, we focused on users' complaints contained in 1- or 2-star reviews. In comparison with the high-rated reviews, these low-rated reviews are more likely to reflect users' concerns and shed light on gaps that should be considered, but that, unfortunately, have been ignored in current research and practice. In total, we analyzed 258 1- and 2-star reviews. When preprocessing the data, we removed stop words and represented each document using the well-known term frequency inverse document frequency (TF-IDF) weighting scheme (Haddi et al. 2013). In order to adopt this weighting scheme, we treated each user review in the dataset as a document. Specifically, TF-IDF weight of a word i in a user review j is given by

$$F_{i,j} * \log\left(N/\mathrm{DF}\right)$$

Where $F_{i,j}$ is the frequency of the word i in the user review j, N indicates the number of user reviews in the corpus, and DF is the number of user reviews that contains word i.

3.2 Topic Modeling: LDA

Topic models are statistical-based algorithms for discovering the main themes (i.e., set of topics) that describe a large and unstructured collection of documents. Topic models allow us to summarize textual data at a scale that is impossible to be tackled by human annotation. We selected the LDA model, the most common topic model currently in use, due to its conceptual advantage over other latent topic models (Blei et al. 2003). The model generates automatic summaries of topics in terms of a discrete probability distribution over words for each topic, and it also infers per-document discrete distributions over topics. The interaction between the observed documents and hidden topic structure is manifested in the probabilistic generative process associated with LDA. This generative process can be thought of as a random process that is assumed to have produced the observed document (Bao and Datta 2014). In order to illustrate the results of LDA, let M, K, N, and V be the number of documents in a collection, the number of topics, the number of words in a document, and the vocabulary size, respectively. The first result is an $M \times K$ matrix, where the weight $w_{m,k}$ is the association between a document d_m and a topic t_k. In our case, the documents are user reviews for patient portal mychart app (i.e., we integrated the reviews of the app in a data file and treated each user review as a single document) ($M = 258$). The second result is an $N \times K$ matrix, where the weight $w_{n,k}$ is the association between a word w_n and a topic t_k. The notations $Dirichlet(\cdot)$ and $Multinomial(\cdot)$ represent Dirichlet and multinomial distribution with parameter $(\cdot)$, respectively. The graphical representation of LDA is shown in Fig. 2, and the corresponding generative process is shown below:

```
(1) For each topic t∈ {1, ..., K},
     (a) draw a distribution over vocabulary words
         β_t ~ Dirichlet(η).
(2) For each document d,
     (a) draw a vector of topic proportions
         θ_d ~ Dirichlet(α).
     (b) For each word w_n in document d, where
```

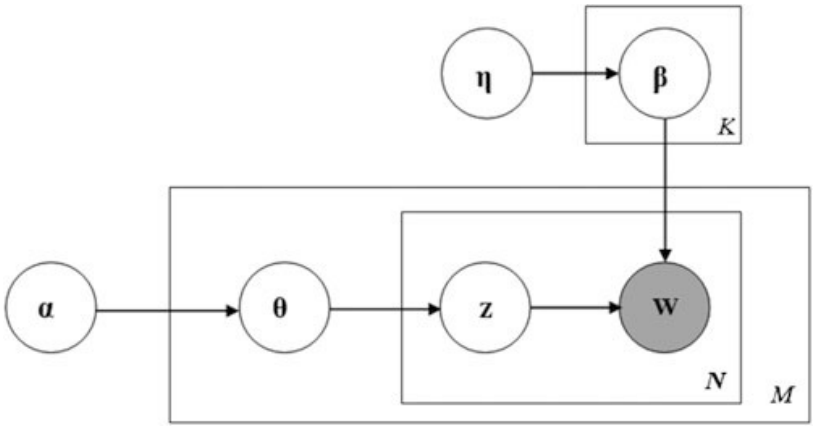

Fig. 2 Graphical model of LDA

$n \in \{1, \ldots, N\}$,
(i) draw a topic assignment
$z_n \sim \text{Multinomial}(\theta_d)$;
(ii) draw a word $w_n \sim \textit{Multinomial}(\beta_{zn})$.

The notation β_t is the V-dimensional word distribution for topic t, and θ_d is the K-dimensional topic proportion for document d. The notations η and α represent the hyperparameters of the corresponding Dirichlet distributions.

4 Results

4.1 Gaps Discovered

In this section, we summarize and discuss the results of the extraction of the topics of the users' negative experience (i.e., gaps of mobile patient portal). We apply LDA to extract and label the topics of users' concerns across all collected low rating reviews of mychart portal in our sample. The LDA identified 25 topics and, within each topic, showed the top-10 words and their relative weight (i.e., probability). The naming of topics was first conducted by the first author and confirmed by the second author. Naming was initially based on the identification of a logical connection between these 10 most frequent words for a topic. For example, in Table 1, the topic name "Way to update and schedule appointment" is based on the words "Appointments," weighted 1.3%; "update," weighted 0.9%; and "Schedule," weighted 0.7%, which appear at the top 10 words. Once we specified a candidate topic label, we further tested it via investigating the reviews that are highly associated with that topic.

Then, we mapped the topics we obtained into 10 design gaps, which Table 2 shows along with examples from user feedback. The mappings between the topics and the gaps were sometimes one-to-one. For instance, the topic "notifications" was

Table 1 Examples of identifying topics labels

Topic 1: Way to update and schedule appointment	Weight (%)	Topic 2: Log in using touch ID	Weight (%)
Needs	1.5%	ipad	1.0%
Appointments	1.3%	Beneficial	0.9%
App	1.0%	Available	0.8%
Info	0.9%	Log	0.8%
Update	0.9%	Id	0.8%
Updated	0.8%	App	0.8%
Way	0.7%	Touch	0.8%
Unable	0.7%	Alert	0.8%
Schedule	0.7%	Longer	0.7%
Ability	0.7%	Topic	0.7%

Table 2 Identified gaps, supported by examples from user feedback

Gap	Examples from the user feedback
Gap 1: Appointments management This gap refers to patients' inability to manage their appointments over the portal. For examples, they cannot request, schedule, print, track appointments and cannot even view their appointment schedule in an appropriate format	Can't even schedule or request an appointment with it. Just downloaded the app, but could not schedule appointments on iPhone or iPad. You no longer can read your appointment schedule or any information in a normal sentence Appointment layout horrible
Gap 2: Notifications/alerts This gap pertains to the lack of providing patients with notifications/alerts when a doctor has new results or a message for them, or when they have an upcoming appointment	Needs notifications/alerts. Useless if not notified of the important messages received within the app. Unable to find any way to enable notifications Please add an email alert option! I can't even get new notifications when my doctor has a new results or a message for me I can't believe that there has been another update and still no push notifications
Gap 3: Integration with other health apps This gap relates to not having the portal (Mychart) integrated with other health apps (e.g., FitBit and Apple HealthKit), so that patients can synchronize their health data both ways, from Mychart to health apps (like lab results) and from health apps to Mychart	No sync with Apple Health The MyChart app should integrate with Health on iOS. Ideally, lab results would be sourced from MyChart and feed into Apple's Health. iOS Health data should be read by MyChart and placed in to a message or a report for my physician
Gap 4: Communication with health providers This gap refers to patients' inability to communicate well with their health providers via the portal. In this regard, patients neither can exchange messages with health providers nor send them their test results	This app doesn't give you the option to reply when you get a msg from your doctor. You have to send a new msg No way to send test results to doctors I cannot send my doctor any messages Actually makes communicating with your doctor harder Need to add the feature of getting messages from doctors I want to read sent emails
Gap 5: Security issues This gap refers to the absence of the "Touch ID" feature, which allows patients to log in using their fingerprint, and to patients' inability to manage their password	Why isn't Touch ID available I would really like Touch ID support for logging into my provider, instead of entering my password every time It also lacks integration with popular password managers, such as 1Password For many of us who have multiple changing passwords this app is a nightmare

(continued)

Table 2 (continued)

Gap	Examples from the user feedback
Gap 6: Access and retrieve data This gap refers to patients' inability to access and retrieve health related data like diagnostic or bloodwork info, weight, bp, medical tests or history	I have several health data about my sleep, exercises, and some more that my doctor would love to have access to Can't access any of my diagnostic or bloodwork info Cannot access my weight, bp, etc. record Cannot access to any of the medical tests or history Miss a lot of information especially in the health summary it's not an exact copy of your medical records Cannot retrieve any data since most recent update
Gap 7: Informative presentation (data to knowledge presentation) This gap refers to patients' inability to track their health with graphs/charts and to display their health data at multiple levels of aggregations, "drill-down" and "roll-up", on Dashboard	No ability to track health with graphs or charts Instead of displaying data on Dashboard in discussions with doctors, I have to manually download data to a spreadsheet (unneeded waste of effort) Also, the Health Summary: Heath Issues; section is a weird subset of random one liners, none of which are clickable to get more information. I wish it was much more complete with all the notes my doctors have written
Gap 8: Update medical data This gap refers to patients' inability to update/correct/upload medical data, such as blood pressure	Upload updated insurance cards and be able to indicate which one is the primary and which one is the second one It be great if I could update my shots and other medical issues Gives no ability to patient/user to correct/update data. Have to request medical personnel to make changes Should be able to upload common health metrics like blood pressure Add support to upload pdf files
Gap 9: Install/open the app This gap refers to patients' inability to install and open the app	Haven't been able to open the app for weeks now I can't open or use this app Problems downloading and installing Cannot install on iPhone 7 plus
Gap 10: Communicating with server problems This gap refers to patients' inability to connect to the server sometimes	Keeps saying cannot connect to server Down more than a week. Can't communicate with the server Will not let me sign in to my chart from Cleveland clinic, and it keeps saying Problem communicating with the server

mapped to the gap "Notifications/alerts" and the topic "information summaries" to the gap "Informative presentation". There are also some gaps that correspond to multiple topics. For example, the "Appointments"-related topics (i.e., "way to update and schedule appointment", "Print appointments", "track appointments with providers", and "update appointment") were mapped into the gap "Appointments management."

4.2 Validity of Gaps Discovered

We examined the validity of the extracted gaps by comparing the results of LDA analysis with that of human analysis (see Table 3). In order to conduct the manual analysis, we adopted open coding technique for data analysis. Two independent researchers read the collected 1- and 2-star reviews and then identified the gaps which were mentioned in these reviews. We compared the gaps derived from the LDA analysis with the ones the two researchers identified, to calculate the reliability of the LDA result. The Jaccard coefficient[1] is 0.71 and 0.6 between the automated analysis and the two researchers, A and B respectively. As Table 3 shows, the manual coding of the data revealed four new gaps: "Export/Import data", that refers to the inability to export and save health data to files, "Support multiple health providers", "Technical support", and "Billing issues".

Table 3 A comparison of gaps between LDA analysis and human analysis

Gap	LDA analysis	Researcher A	Researcher B
Appointments management	√	√	√
Notifications/alerts	√	√	√
Integration with other health apps	√	√	√
Communication with health providers	√	√	√
Security issues	√	√	√
Access and retrieve health data	√	√	√
Informative presentation (data to knowledge presentation)	√	√	√
Update medical data	√	√	x
Install/open the app	√	√	x
Communicating with server problems	√	√	√
Export/Import data	X	√	√
Support multiple health providers	x	√	x
Technical support	x	√	√
Billing issues	x	√	√

[1]The Jaccard coefficient measures similarity between finite sample sets, and is defined as the size of the intersection divided by the size of the union of the sample sets.

5 Conclusion

The rising cost and decreasing quality of healthcare has raised the impetus toward the use of patient portals and EHRs, in order to overcome these issues with the increased transparency and efficiency that the technology allows. However, the challenges of patient portals have tempered efforts to improve efficiency of healthcare through the technology. This paper aims to investigate the gaps in mobile patient portal service to enable patient-centered care by analyzing the actual use of these systems. We adopt a text mining-based approach to leveraging online user reviews as a primary data source. Given the market prominence of EPIC's mychart patient portal, we use it as a problem domain.

The results of this research identified opportunities for improvement from patients' perceptions. Several gaps emerged, which reveal opportunities to enhance the design of portals intended for patient-centered care. These important findings can inform design decisions to promote use and foster engagement. Overall, optimizing a mobile patient portal will require careful attention to particular functionalities to enable collaboration, such as allowing patients to request and schedule an appointment by "Appointments management" and notifying them regarding new results and messages by "Notifications/alerts". It is also paramount to enable patients to "Communicate with health providers", "Export/Import" their health data, and use their fingerprint to log in "Security issues". Also, the portal should be "Integrated with other health apps" (i.e., fitness apps). We found also that patients were interested to having the ability to update their health data (e.g., shots and common metrics such as blood pressure) as well as update insurance information (i.e., insurance cards).

Regarding the portal content, patients described the utility of accessing and retrieving health data (e.g., test results and prescription) and patient's information (e.g., weight and blood pressure). This finding is consistent with O'Leary et al.'s (2016) research, demonstrating that hospitalized patients have a strong interest in all types of test results. It is also crucial that the portal provide patients with readable and informative graphs, reports, and charts of their health-related data, depicting their improvement patterns and historical trends in "Informative presentation". In order to achieve better quality of care, the patient portals can provide the transparency needed, as patients utilize the technology to support patient interaction, and enable patients to access the information they need to make better decisions about their healthcare. These changes will positively influence patient-centered care.

For the future, it is difficult to see anything other than refinements and growth of current healthcare strategies to utilize technology to improve patient engagement and support (Cliff 2012; Kane and Labianca 2011). The expansion of patient portals, chronic disease apps, and educational tools to support patients are expected to grow at increasing rates (Cohen et al. 2010; McAlearney et al. 2016; O'Leary et al. 2016). The use of connected health solutions is becoming standard practice among hospitals in the U.S., as 81% of hospitals leverage this type of IT (IOM 2001).

According to a 2016 HIMSS survey, 47% of respondents emphasized personal technology to influence patient satisfaction, treatment monitoring, patient engagement, and patient education. These individuals planned on continuing to grow in these areas (IOM 2001). Patients want to be engaged in their healthcare decision-making process, and those who are engaged as decision-makers in their care tend to be healthier and have better outcomes. However, the change from episodic-based care to life care will be a long transition. The way we pay for healthcare and the way we deliver healthcare are changing. Technology advancements will play a role in empowering and engaging people before they become patients. The culture change will be similar to other health culture changes like smoking and seatbelts.

This study contributes to the design and development of future technologies (Al-Ramahi et al. 2015). As technological advances continue, healthcare stakeholders agree: "Prepared, engaged patients are a key stepping stone toward high-quality care, lower costs, and better health."

Theoretically, this work contributes to the existing knowledge base of mobile patient portal design by presenting some existing opportunities for design enhancements and inferring new ones. Methodologically, this study exploits users' feedback in form of online reviews. In essence, the design of mobile patient portals requires understanding of users' perceptions and concerns. In this regard, user involvement is key in portal systems design, which can help shift the focus of innovation from pure technology to the context of daily life (Thackara 2001). Hence, we developed and presented opportunities for design enhancements based on users' reviews.

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