Field Test of a Questionnaire-based Mobile Health Reporting System

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Figure 1: Illustration of the development process of IBDsmart: flow chart (left), hifi prototype (centre), and final software as used in field test on Android phone (right)

ABSTRACT

There is increasing demand to improve the quality and efficiency of healthcare delivery. Mobile health self-reporting can play a vital role here, provided that user acceptance can be achieved. We developed a mobile health reporting app for patients suffering from inflammatory bowel diseases and tested its acceptance, perceived usefulness and usability in a field trial with 35 patients over a period of eight weeks. Participants selected were already accustomed to filling in questionnaires about their health and well-being (albeit less frequently and post-hoc). Therefore we designed and implemented an interface emulating this form of interaction as closely as possible. This approach proved to be successful: our participants in the field study attested to the feasibility of this approach as indicated by the data presented here. With our example, we can show that for an effective transition to electronic/mobile systems, it should be possible to minimize the gulfs of execution and evaluation.

Author Keywords

Mobile health care, mobile user interfaces, usability and utility, field research

ACM Classification Keywords

H.5.2 User Interfaces: *Evaluation/methodology*

INTRODUCTION

Nowadays health care delivery is challenged by the demand to deliver higher quality with fewer resources. The collection of data on patients' health and well-being during doctor visits is one such domain. Fortunately, current technology can support healthcare patients and professionals in the process of data collection and analysis (Boulos et al., 2011). As examples, variables such as heart rate, activity, body temperature, and blood glucose levels can be acquired in real-time. Assistive technologies such as these are often termed Pervasive Health, and mobile technology is a key enabler in this field. Mobile phones include inbuilt integrated sensors (e.g. measuring acceleration for fall detection) and can often be extended by connecting them with external sensors (e.g. for blood glucose measurements). Mobile phones also integrate communication technology capable of sending reports and, if required, providing immediate feedback (e.g. in case of emergency). In these ways mobile technology can be used for immediate alarm notification, and allows for continuous data collection of quantity and quality measurements. As it is essential for patients to be well informed and in charge of their disease management (in combination with a close contact to the specialist/IBD nurse) (Pedersen et al., 2012), such collected data allow for new directions in individualised intervention, and for enhanced diagnosis models. It has also been shown that mobile technologies are able to successfully deliver health interventions to traditionally hard-to-reach populations (Agarwal & Lau 2010).

We chose to explore an approach that adopts and mimics current paper-based practice for delivery on mobile systems. In this way, patients can continue with existing practices (e.g. questionnaires that they are accustomed to) and behaviours (filling out questionnaires when specified medical conditions occur). This approach aims to minimise the gulfs of execution (How does the user know what to do?) and evaluation (How does the user know what happened?) (Norman & Draper, 1986) in that the patients can continue following known procedures while only changing the questionnaire delivery medium (digital on mobile phone in place of printed paper).

Furthermore, despite the advances in mobile and wearable technology, in particular for health-monitoring sensors, some health parameters cannot be easily quantified using sensors. Examples of this are the perception of general wellbeing, felt pain, or visible disorders that require advances in image computations (e.g. flushing on the face). However, self-assessment could identify the symptoms and any patterns in their occurrence. Mobile technology could also support these cases but acceptance of the technology is a key requirement for success. While in theory many analogies can be drawn from the Quantified Self movement (http://quantifiedself.com), in practice patients cannot be considered as volunteers – consequently posing different challenges.

In the following, we present our research on a questionnaire-based mobile health reporting system aiming towards patients with Inflammatory Bowel Diseases (IBD), building on our existing collaborations between informatics and gastroenterology.

IBDSMART SYSTEM

Inflammatory Bowel Diseases (IBD) is a group of chronic intestinal disorders affecting people of all ages but developing mainly in teenage years. Therapy is usually implemented through an individualized schedule for each patient, also using an individualized set of drugs. This personal plan is based on the patient's history and the current severity of the disease, among other parameters. The current severity can be assessed using standardized and validated paper-based questionnaires and scoring systems such as Simple Clinical Colitis Index (SCCAI, Walmsley et al., 1998), Harvey Bradshaw Index (HBI, Harvey & Bradshaw, 1980), Crohn's Disease Activity Index (CDAI, Best et al., 1976), and the Dudley Intestinal Symptom Questionnaire (DISQ). The choice of questionnaire depends on the condition itself, is normally time-consuming, and is therefore reluctantly used, but is mandated by the Ministry of Health for prescription of expensive medications.

Basing our specifications on the existing paper-based questionnaires we, as a group of informatics and medical specialists, created the IBDsmart system for mobile hardware. The intention is to display digital, tailored versions of the original questionnaires and scales to each patient. Delivery of these can be scheduled by medical personnel or initiated by the patient, producing scores to be interpreted by the doctor or nurse. Also results reflecting the current severity of each patient's disease can be automatically sent to care-givers who can decide on immediate actions (e.g. to contact the patient) or schedule new questionnaires for display to the patients. The results are always logged in a database for incorporation into the patients' individual health histories.

We constructed our prototype using standard Android GUI elements, extended them to support more complex GUI elements (e.g., Likert-type scales) and also implemented a mechanism to dynamically generate the elements into the questionnaire them out of a configuration file (see Figure 2). The configuration file is hosted on a secure remote server allowing medical staff to alter it. The new configuration is loaded at application start-up provided an internet connection is available. The medical staff receive updates from each patient whenever a questionnaire is completed. The updates are automatically pushed to a clinical data collection service while a nurse also receives the updates which (for the time being) are still manually entered into an existing clinical database. If poor internet connectivity prevents delivery of a data the IBDsmart program will automatically retry the transmission at the next application start-up.

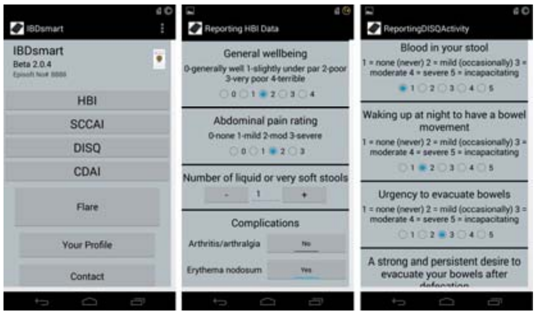

Figure 2. UI examples of implemented interface in electronic questionnaire format

FIELD STUDY

We conducted a field study over several weeks with actual patients suffering from IBD. They all used our mobile health application and provided quantitative feedback using a questionnaire (separate from system).

Aim

Inflammatory Bowel Diseases are characterized by periods of remission and periods when the disease is active. During active periods patients often require prompt medical assistance and advice. IBD nurses seek further information on patients' symptoms, indicative of a flare-up and also to gain access and to validate effectiveness of restricted medications used in the treatment of IBD.

The aim of this study was to test the acceptance and usability of mobile help applications in gaining this information from patients via a smart phone application.

Method

The IBD nurse recruited patients in the hospital with Crohn's Disease (CD) or Ulcerative Colitis (UC) aiming for an equal number of males and females in three age groups (18-34, 35-54, >55) with 10 persons within 18-34 years, 14 within 35-54 years, and 11 aged 55 or higher. No formal power calculations were performed but this was felt sufficient to provide sufficient feedback about the system and allow for statistical comparisons between groups of interest (age group and disease group). Depending on disease, patients completed the Simple Clinical Colitis Index (SCCAI), Harvey Bradshaw Index (HBI), Crohn's Disease Activity Index (CDAI) and the Dudley Intestinal Symptom Questionnaire (DISQ). Patients were then asked to complete a questionnaire on acceptance and usability.

All users downloaded IBDsmart to their phones and were introduced to the use of the system by the IBD nurse. Almost two thirds (n=23/35) of the patients did not own a smart phone suitable for our application (Android 2.3 Gingerbread) so were provided with devices for the duration of the field trial. We asked the patients to complete the questionnaires regarding their current IBD symptoms at least five times over eight weeks.

At the end of the trial we asked the participants to complete an additional acceptance and usability questionnaire on their experience with our mobile health app. This was partly derived from IBM's user satisfaction questionnaire (we adhered to the 7-point Likert-type items with 1-Strongly Disagree and 7-Strongly Agree).

- Q1: Overall, I am satisfied with how easy it is to use this system.
- Q2: I could effectively complete the tasks (reporting, entering my data) using this system.
- Q3: I was able to complete the tasks (reporting) quickly using this system.
- Q4: I was able to efficiently complete the tasks (reporting) using this system.
- Q5: I felt comfortable using this system.
- Q6: It was easy to learn to use this system.
- Q7: I would like to see a tracking of my disease severity scores to see if I have improved or not.
- Q8: Could IBDsmart replace a visit to the specialist?

Q8 was intended to address possible future directions in the application of health monitoring systems. The acceptance and usability questionnaire was collected from each participant after the eight weeks of usage.

Appropriate descriptive statistics are presented. Spearman's correlation coefficients for pairs of questions were investigated. Associations between categorical variables were investigated using Fisher's Exact tests. Linear regression models were used to explore the associations between the above eight questions and both age group and disease group. Initially age group-disease group interactions were examined and if the Wald test was not statistically significant, a main effects model with age group and disease group was used. In a subsequent analysis, *use of their own phone* was added to the models containing age and disease groups. Standard regression diagnostics were examined and log-transformations were investigated to see if this improved residual normality and homoscedasticity. Results from the regression models are reported as differences in arithmetic means with 95% confidence intervals. Stata 13.1 was used for all analyses and two-sided $p<0.05$ was considered statistically significant in all cases.

Results

Of the 36 recruited patients, 35 completed the project while one person dropped out of the study. Of the 35 participants 29 were in remission (83%). When splitting the results from the 7-point Likert-type scales into 1/2 (clearly disagree), 3/4/5 (neutral), and 6/7 (clearly agree) we see that overall at least 74% of the responses were clearly positive with respect to the general usability of the system (for each of Q1–6). When looking at the individual usability questions we saw also very similar ratings across the questions (M±SD) with Q1 (6.0±1.0), Q2 (6.1±1.2), Q3 (6.4±0.8), Q4 (6.3±0.9), Q5 (6.4±1.0), and Q6 (6.3±1.1).

The remaining questions about the tracking of the disease severity scores (Q7) and on replacing visits to specialists (Q8) scored lower with Q7 (5.7±1.5) and Q8 (3.3±2.0). The lower results were also reflected in the amount of clearly positive replies, which were 66% (Q7) and 17% (Q8). The majority of participants (46%) clearly disagreed with Q8, although we do not have reasons for this. The correlations between all six user satisfaction questions (Q1-Q6) were moderate to high (for all pairs Spearman's rho≥0.61, $p<0.001$). There was no evidence of any associations between any of the six user satisfaction questions (Q1-Q6) and belief about IBDsmart replacing specialist visits (Q8) (all p≥0.257).

There was no evidence of any interactions between age group and disease group (all p≥0.145). When looking at effects of the participant's age group on the responses (adjusting for disease group) we found significant lower scores with increasing age for Q6 (ease of learning, Wald p=0.004, difference between youngest and oldest group 1.38 points, 95% CI 0.57–2.19, p=0.002 and between middle and oldest group 1.03 points, 95% CI 0.28–1.77, p=0.009). There was a non-statistically significant tendency for Q3 (p=0.062), with lower scores among the older age groups.

From the adjusted models, there was evidence of higher scores in terms of (Q1) satisfaction (0.81, 95% CI 0.15–1.46, p=0.017), (Q2) effectiveness (0.95, 95% CI 0.22–1.69, p=0.013), and (Q3) speed (0.54, 95% CI 0.06–1.01, p=0.028) for those with UC compared to CD. This group also agreed more that IBDsmart could (Q8) replace a visit to the specialist (1.69, 95% CI 1.08–2.64, p=0.022). There was also a non-statistically significant tendency towards higher scores for (Q4) efficiency (p=0.098).

We also analyzed effects resulting from using a loaned phone instead of a personal phone. There was no evidence of associations between phone use and either age group (Fisher's Exact p=0.739) or disease group

(Fisher's Exact p=1.000). Adjusting for age group and disease group, there was no evidence that phone use was associated with higher or lower satisfactions for questions Q1, Q2, Q4, or Q6 (all $p \geq 0.162$) but there were statistically significant lower levels of agreement for question Q3 (speed) for those using their own phone (0.52 lower, 95% CI 0.05–1.00, p=0.032) and a non-statistically significant tendency for lower ratings to question Q5 (comfort, 0.60 lower, 95% CI -0.08–1.27, p=0.080).

Discussion

Overall the results show that IBDsmart was well accepted by patients with IBD and achieved a high usability reporting. It was not surprising to find that it was harder for older patients to learn the handling of the app. It was also not surprising to see that people using their own, possibly outdated, phone agreed less on how quickly they solved tasks using the system. Even so, in both cases the users gave high ratings, which is an encouraging result. This also indicates that medical staff could distribute mobile technology on loan in case the personal hardware is not present or capable enough, and that users among the ageing population still have a positive experience.

Patients with UC gave higher ratings than patients having CD (often a more complex form of IBD with no simple treatment algorithms). This result can be well explained for Q8 by stating that IBDsmart and similar applications are more likely to assist less complex cases while more complex cases want a closer contact with medical staff. The significant difference in usability-related questions is surprising, one interpretation could be that general lesser wellbeing leads to a decreased usability rating.

Conclusion and Future Work

We presented a questionnaire-based mobile health reporting system for Inflammatory Bowel Diseases. The system is based on existing paper-based questionnaires but implemented on a mobile platform. Additionally, our implementation allows medical staff to control the questionnaires' contents and schedules based on the data received from the patients.

Our results suggest that IBDsmart was well accepted by patients with IBD as a tool to monitor disease severity. Adoption might be easier for younger patients and those with UC. While the first aspect seems obvious, given the familiarity with mobile technology, the latter aspect needs more investigations for disease specifics, in particular to identify potential confounders.

It remains to be investigated whether mobile health apps can replace some doctor consultations. Mobile health applications are able to better monitor patient conditions, even if this data is manually entered by the patients, as with our system. They allow for a more immediate monitoring rather than retrospectively at consultation time. Future work consequently should focus on interfaces that further support personal contact via the mobile application to reduce (but perhaps not replace) visits to specialists – e.g. via chats, videoconference tools, or other forms of synchronous or asynchronous communication.

Future systems will give patients more control over their treatment, which might receive tailoring recommendations from the system in response to the patients' questionnaire responses.

Finally, even if UC and CD patient groups both rated the usability of our IBDsmart app highly, there were differences between these groups. This indicates that future developments for mobile health-monitoring apps should be, at least initially, tailored to the specific targeted disease. Here, again, closing the gulfs of execution and evaluation by developing from techniques that patients are familiar with, might be key.

Based on the lessons learnt from this study we are currently developing a new version of our system (Android and iOS) for further testing. We will report on particular usability features of the design in due course.

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