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The Shared Decision Making Frontier: a Feasibility and Usability Study for Managing Non-Critical Chronic Illness by Combining Behavioural & Decision Theory with Online Technology

Amina Russell[a], William Van Woensel[a], Samina Raza Abidi[b]

[a] *Department of Computer Science, Dalhousie University, Halifax, NS, Canada*
[b] *Department of Medicine, Dalhousie University, Halifax, NS, Canada*

Abstract

The objective of this study is to determine if shared decisions for managing non-critical chronic illness, made through an online biomedical technology intervention, us feasible and usable. The technology intervention incorporates behavioural and decision theories to increase patient engagement, and ultimately long term adherence to health behaviour change. We devised the iheart web intervention as a "proof of concept" in five phases. The implementation incorporates the Vaadin web application framework, Drools, EclipseLink and a MySQL database. Two-thirds of the study participants favoured the technology intervention, based on Likert-scale questions from a post-study questionnaire. Qualitative analysis of think aloud feedback, video screen captures and open-ended questions from the post-study questionnaire uncovered six main areas or themes for improvement. We conclude that online shared decisions for managing a non-critical chronic illness are feasible and usable through the iheart web intervention.

Keywords:

Shared Decision Making; Behavioural Medicine; Choice Architecture; Biomedical Technology Intervention; Chronic Illness.

Introduction

Shared decision making (SDM) is considered the cornerstone of patient-centred care [1], signifying an important paradigm shift away from paternalistic medicine. In SDM, the patient and physician collaborate to select the best diagnostic and treatment options. It is a meeting of experts, in which the physician is the expert in medicine and the patient is the expert in his or her own life, values and circumstances [2].

Clinical trials have demonstrated that SDM can improve adherence to treatment and clinical outcomes [3, 4]. Despite its proven effectiveness, literature shows that only 10% of face-to-face clinical consultations involve SDM [5]. Biomedical technology interventions, also known as decision aids, have sought to fill this SDM gap [6]. Web-based apps aimed at improving lifestyles (i.e., weight change, nutrition, and physical activity) show evidence of positive impacts [7]. One study [8] concludes that web-based interventions increase patient activation and have the potential to enhance the self-management capabilities of the growing population of chronically ill people. A systematic review of internet-based interventions for hypertension revealed they significantly reduced systolic blood pressure by 3.8 mm Hg and diastolic blood pressure by 2.1 mm Hg [9]. In the Netherlands where heavy drinking among young adults has become a public concern, a tailored web-based intervention aims to reduce drinking practices amongst college students [10].

Use of behavioural theories improves the success rate of these health interventions [11]. For example, theory-driven behavioural strategies can reduce the risk of cardiovascular disease through lifestyle change rather than increasing medication [12]. Many different behavioural theories exist such as the Integrated Change (I-Change) behavioural model which has three simple states: awareness, motivation and action [13]. Its straightforwardness makes it a good fit for biomedical technology interventions, which should be kept simple as they involve patient interaction.

Choice architecture (CA) is another technique for improving decisions, as well as their implied long-term behaviour change (e.g., reduce smoking) [14]. CA is a decision theory originating from the field of economics [15] and has been successfully used to improve adherence to medication use [14]. It serves to fill the well-known intent-behaviour gap [16], characterized by a disconnection between intention and actual behaviour.

Reinforcement through multiple methods may increase patient motivation, and adherence to decided-upon health changes [17]. Both behavioural and choice theories are strategies aimed at improving patient engagement, which is an essential ingredient to SDM. The objective of this study is to demonstrate that behavioural theory and decision theory can complement one another within a technology intervention for SDM.

Methods

The iheart web application is a "proof of concept" to determine whether SDM for the management of a non-critical chronic illness, using a biomedical technology intervention, is feasible and usable. In the software development lifecycle, feasibility determines whether it is sensible to develop a system by objectively reviewing its strengths, weaknesses and opportunities, for instance via proof-of-concept functional prototypes [18]. Usability according to the ISO 9241 standard is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use [19].

The iheart solution evolved over five phases: 1) conceptual, 2) design, 3) application development, 4) testing and 5) assessment of feasibility and usability.

Conceptual Phase

The initial blueprint for the biomedical technology intervention, employing the I-Change behavioural theory and CA, was first defined in a conceptual process flow diagram. The diagram visually outlined the patient navigation when using the system, indicating the different choices and SDM steps between patient and provider.

Design Phase

This conceptual diagram informed the application design. Firstly, the employed behavioral theories, SDM steps, and domain-specific content (i.e., related to hypertension) were represented as an ontology knowledge model. The logic rules for the application, including the SDM logic, were documented externally in decision tables, along with domain-specific messaging.

For hypertension, behaviour change choices include increasing exercise, reducing smoking or reducing sodium. Depending on their current lifestyle, the patient is presented with one or more of these options, and chooses one based on SDM with the healthcare provider. Afterwards, the patient fills out a behavioural questionnaire, which scores his/her initial I-Change behavioural state. I-Change is a behavioural theory with three behavioural states (awareness, motivation and action) and determines the patient's readiness for making the selected behaviour change. Importantly, this state informs elements of the CA, a decision theory that attempts to fill the intent-behaviour gap. In particular, based on the patient's behaviour state, appropriate CA messaging was presented, adapted to his/her readiness for making the selected behaviour change. An expert in Industrial-Organizational Psychology devised and validated the behavioural questionnaire. Questionnaires, content and informational messages were further reviewed by a nurse to ensure they were patient appropriate and also met patient education readability guidelines [20]. Finally, the patient was able to set a concrete goal given his/her health, again during an online SDM chat session with the healthcare provider.

The ontology model was built to be flexible, accommodating any disease condition, the selection of different behavior change theories and different CA concepts; as well as scalable, to support multiple health care providers and patients. This patient-centric model further contained the core constructs, relationships, content, messages and description logic that formed the foundation for the technical solution.

We devised mock screens based on the ontology model, rules and conceptual flow. An entity-relationship diagram defined the underlying database model for the application.

Application Development

The biomedical technology solution consisted of a web-based interface storing information on a centralized server within a secure relational database (Figure 1). The Vaadin open source web application framework [21] was used to produce an internet application accessible on PCs and mobile devices. Vaadin has a plug-in for chat sessions that enabled online SDM.

The iheart data was physically stored in a MySQL database [22] on a secure server. Eclipselink [23] was used to automatically persist application objects in the database, and implement the Java Persistence API (JSR 317) [24]. The Drools business management system [25] implements the Java Rules Engine API (JSR 94) [26], and was used for implementing decision logic based on decision tables. This decision logic included suggesting behaviour changes, based on the patient's current lifestyle; and determining CA messages depending on the patient's I-Change behavioural state. Finally, the Big Life Sodium Calculator [27], a third party web service, was made accessible from iheart, and calculated the participant's daily sodium consumption based on a series of questions.

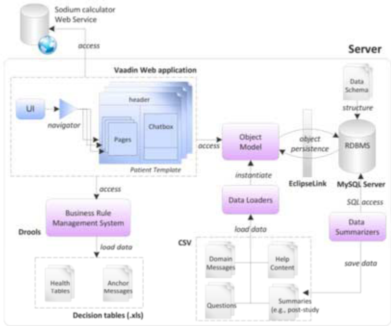

Figure 1 – iheart application architecture

Testing Phase

SDM via an online chat system (Figure 2) represents a novel approach for healthcare. Thus, several rounds of testing were applied to objectively prepare the system for evaluation. First, two medical doctors and two hypertensive patients critically reviewed the first-cut of the iheart prototype. Adjustments followed in response to this initial, informal feedback.

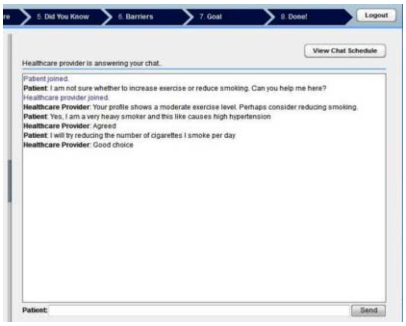

Figure 2 – iheart decision making and chat box

The formal application testing involved both white box and black box testing. An inward look at the application (white box) focused on unit and integration testing of internal components. An outward look at the application (black box) tested its external and user facing features. For example, the black box portion validated the seamless use of the Big Life Sodium Calculator web service within iheart. During both types of testing, modifications were made in iterations followed by regression testing of the application.

Study Assessment

The assessment of iheart was completed through a pilot study approved by the research ethics board of Dalhousie University, Canada. Only four to five subjects are needed to identify 80% of the usability problems with a system [28]. The study recruited nine hypertensive participants, approximately twice the recommended number, from the local area for this purpose.

Three goal-based scenarios were devised in collaboration with a medical doctor to assess the feasibility and usability of iheart. The scenarios were intentionally devised to present more than one lifestyle choice for reducing hypertension. This would compel the participants to make shared decisions. Each participant completed two of the three scenarios in order to sufficiently assess and rate the iheart application. Each scenario was used six times by the pool of nine participants.

This ensured uniformity and consistency in the assessment of the application.

Results

Quantitative Analysis

A post-study questionnaire solicited the participant's usability scores using a five-point Likert scale, combined with open ended questions for capturing experience and thus allowing qualitative analyses (see next section). The questionnaire contained sections on the usability, content, CA, SDM and overall functionality of iheart. The Likert Scale used: 1=Strongly Agree, 2=Moderately Agree, 3=Neither Agree nor Disagree, 4=Moderately Disagree and 5=Strongly Disagree. A score of 1 or 2 favoured iheart whereas scores of four or five indicated discontentment.

The questionnaire contained 41 Likert scale questions. Statistical software calculated the mean, median and mode scores within each section of the post-study survey (Table 1). Further analysis transpired at the participant level (Table 2).

Table 1 – Section Level Data

Section	Mean	Median	Mode	Chronbach's Alpha
Usability	2.07	1.5	1	0.97
Content	2.35	2.0	1	0.94
Choice	1.98	1.0	1	0.85
SDM	2.09	1.0	1	0.95
Overall	2.13	1.0	1	0.97

Within survey sections in Table 1 showed participant satisfaction across the board. Chronbach's alpha validated response consistency within survey sections.

Table 2 – Participant Level Data

Participant	Mean	Median	Mode
p1	1.44	1.0	1
p2	1.34	1.0	1
p3	1.80	1.9	1
p4	1.05	1.0	1
p5	1.61	1.0	1
p6	3.49	4.0	4
p7	4.24	4.0	5
p8	2.95	3.0	2
p9	1.24	1.0	1

Table 2 demonstrated that six participants (two-thirds) favoured the iheart application while participant 8 appeared neutral, participant six leaned towards dissatisfaction and participant seven appears dissatisfied. This quantitative data, when collated with the qualitative information, identified specific areas for improvement to iheart.

Qualitative Analysis

The study captured qualitative data primarily using the "think aloud protocol" [29]. This protocol captures participant feedback spoken out loud while using iheart to achieve the goal-based scenarios. The software, Active Presenter [30], captured the audio and video feedback including screen captures. Participants also responded to three open ended questions in the post-study questionnaire.

The qualitative data was imported into a qualitative analysis tool, ATLAS.Ti [31]. Inductive thematic coding [32] occurred in two stages: 1) open coding and 2) axial coding [33]. First, a comprehensive code list was increasingly built as each piece of qualitative data was openly coded. Open coding involves reading through the data several times, and labeling chunks of data. Afterwards, the frequency or "groundedness" of each code (Figure 3) was reviewed to identify the most common feedback, either positive or negative (prefixed with a plus and minus sign, respectively).

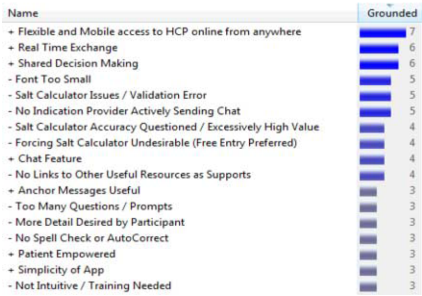

Figure 3 – Participant Feedback by Frequency

Axial coding was then applied to draw categories from the open code list. Axial coding identifies commonalities or relationships amongst the open codes. The "family manager" in the ATLAS.Ti software managed these categories or themes. The derived themes and their frequencies were: communication (10), usability (8), content (8), user interface (9), features (7), chat (6), salt calculator (3) and a miscellaneous (3) category. The themes included both positive and negative feedback, meaning each theme represents areas for improvement. Sorting by theme gives a detailed account of the specific improvements needed. Analysis of the negative feedback showed that all desired improvements were feasible, including functional (e.g., no indication a chat is being sent back), informational (e.g., links to other resources desired) or cosmetic (e.g., font size too small) in nature.

Discussion

A mixed methods study provided rich feedback on possible refinements for the iheart web application. In particular, the qualitative data presented a wealth of information on the benefits and challenges of the intervention that was not apparent in the quantitative data. For instance, the usability section of the post-study questionnaire had a mean score of 2.07, implying the participants moderately agreed the application was usable. Nonetheless, six items were identified in the qualitative analyses to improve the user interface and four items to improve the chat feature. Both the user interface and chat feature contribute to usability.

Additionally, the qualitative feedback identified other practical situations where iheart could be applied to manage chronic illness. In particular, participants felt that iheart would be very useful in general long term care where a physician is not always present onsite. They also saw value in situations where patient mobility is limited (e.g., cannot leave home).

Vision

A notable feature of iheart is its scalability. The application was designed with expansion in mind. The ontology knowledge model accommodates decision-making with more than one health provider per patient to accommodate multi-disciplinary teams of medical professionals providing care. Due to its reusable components, the web application can be customized for other chronic illnesses as well, thus expanding its use to other medical domains.

The study data demonstrates that participants most appreciated the flexibility, mobility, shared decisions and real time chat exchanges with a remote healthcare provider. This suggests a paradigm shift within the practice of traditional medicine. It means medical providers, endorsing a tool such as iheart, would have to accommodate scheduled "chat time" in their daily or weekly schedule to interact online in a real-time fashion with patients. Or, similar to an online call centre, the configuration could include recruitment of a pool of qualified medical professionals to provide real-time interaction with patients. It is the next frontier in online medicine. Patients are increasingly seeking timely and informative medical answers online. Currently, they seek it in the form of static information (e.g., webMD knowledge bases). Based on our study, it seems that online, human interactive exchange is another appealing knowledge medium for patients.

Limitations

A limiting element of iheart was the loss of face-to-face communication currently used in traditional medicine. Some participants expressed that without facial expressions, body language and visual cues, it was difficult to read the healthcare provider and also describe their medical situation adequately. Seeing how patients appreciated the flexibility and mobility of the real-time text-based chats, this challenge could be addressed through the use of a video chat option. Patients could alternatively have a combined video and text chat (much like a Snapchat session) during shared decision points to reduce the communication void from a text-only session.

Future Work

The iheart application should be revised based on the study feedback. Moreover, a logical next step would be performing an efficacy study, to assess adherence to the application's daily use for managing chronic illness such as hypertension. This study should also solicit input and feedback from a larger selection of healthcare providers.

To further assist in decision making, behaviour change choices available during SDM could be accompanied by evidence-based metrics. A health informatics approach could capture each participant's intervention choice and their adherence to the particular behaviour. After a fixed number of participants (e.g., 100) have used iheart, the cumulative data from people with similar demographics could be used to indicate success rates for each behaviour choice.

Conclusion

The majority of study participants positively perceived the iheart application. Think aloud and qualitative feedback identified specific areas for improvement. The desired improvements are all possible with the exception of the salt calculator, which needs to be changed by its creators. Overall, making shared decisions through a biomedical technology intervention proved both feasible and usable.

As Canada's population is set to enter a period of relatively rapid aging [34], we need to pursue innovative means of delivering care. The Canadian trend for elderly patients with chronic illness or low mobility is to seek care in their homes [35]. As indicated by our test subjects, a system like iheart could be a good fit for residential and long term care of non-critical chronic illness. We recommend the revised version of iheart be pilot tested in a variety of settings where patients have low mobility or challenges reaching their physicians.

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Address for correspondence

Amina Russell, Dalhousie University

E-mail: arussell@cs.dal.ca