ABSTRACT
It has been recognized that most seniors prefer to age in a place with familiar surroundings until their health makes this impossible. In an attempt to address the aging phenomenon, as well as recognize seniors’ preference, we worked with a Canada-based company that develops a sensor-based home monitoring system for people to monitor the home activities of independently living seniors. Our role was to develop web interfaces that present sensor data to the intended web users – the seniors’ informal care providers (e.g., their close friends or family members). In this paper, we present the information design and the web interface prototypes, and report the results of our formative evaluations through cognitive walkthrough and heuristic evaluation methods. The common problems discovered in both methods were problematic notification mechanism, inconsistency, background and layout. Each method also detected usability issues that the other did not. Our work adds more empirical evidence to the importance of combining evaluation methods in a study. The experiences in this study also helped us reflect on approaches and strategies when working with industry partners.

Keywords
Aging-in-place, sensor, home monitoring system, web design

INTRODUCTION
The aging of the population has become an important phenomenon to address for many nations. It has been recognized that most seniors prefer to age in a place with familiar surroundings until their health makes this impossible. For example, in a recent survey conducted in Canada, more than 85% of the seniors who are over 55 years old said that they planned to live in their home for as long as possible, even if their health declined (CMHC, 2008). Various technologies have been developed to tackle different issues arose from this phenomenon, such as helping elderly people who live alone to maintain close social ties with others (e.g., Santana et al., 2005), or monitoring their home activities to allow immediate responses in emergency situations (e.g., Junnila et al., 2010).

In a home environment equipped with such system, information and communication technologies collect and analyze data about the environment and activities of any living being inside, which may allow operations of home devices, or notify others who have access to the data of situations that need attention. Many home monitoring systems have been developed both in academia and in industry, e.g., AlarmNET, GatorTech Smart house, WellAWARE, etc. An extensive review of the existing home monitoring systems can be found at (Bal et al., 2011).

The work we report in this paper belongs to an industry-sponsored project to develop a sensor-based home monitoring system. In the project, the Canada-based company collaborated with a national research lab in developing a system that integrates technological innovations with the latest architectural design, building materials and information and communication technologies (ICT) to create functional, independent and safe environments that would allow seniors to live in their homes for longer periods of time. Our role was to develop web interfaces for presenting sensor data to informal care providers of the seniors. In this project, a senior’s informal care providers can be the senior’s family members, friends, or neighborhoods, or anyone else identified by the senior who is willing to provide informal care to the senior when there is a need. The sensor data collected from a home environment include data about motion in different rooms, room temperature, water usage, humidity, etc. The assumption of our work is that the collected sensor data are not only useful to the senior for self-monitoring, but also important to the senior’s informal care providers.

In this paper, we present the designed web interfaces and usability evaluation results from cognitive walkthrough and
heuristic evaluation. We first introduce related work, and then describe the goal of information design for the web interfaces. We then describe the two approaches we used to organize and present the information on the interfaces. We next discuss the cognitive walkthrough and heuristic evaluation methods and how we used them in the evaluation. We present the evaluation results and conclude with the lessons learnt.

**RELATED WORK**
Health information technology is useful only when it is usable and accessible by clinicians, consumers, and other stakeholders. Likewise, the process of developing eHealth tool needs to be monitored and evaluated carefully. If a mistake falls through the crack, the cost of fixing a problem at the end can be ten times as high as fixing it during the design phase. Goldberg et al. (2011) examined the usability and accessibility of health information technologies. They emphasized the importance of understanding users and their context, and suggested the use of “patient personas” to help guide the design.

Taylor et al. (2011) provided a methodological review of a user-centered framework called the Website Developmental Model for the Healthcare Consumer. As the number of people search for health information online increases, it becomes important to develop health websites that consider user characteristics, their general and health literacy levels, information quality of the websites, and human-computer interface designs. The analyses and evaluations methods used in Taylor et al.’s study (2011) included: user/environmental/task/functional analysis, visual-graphical representation analysis, comparative analysis, cognitive walkthrough, heuristic evaluation, standards of practice (HONcode), small-scale usability studies, content-based testing, and expert-based testing. The authors presented a case analysis of a consumer health-related website to illustrate that this framework model can be applied to the initial design or redesign of a consumer health-related website because the final results of the intensive analyses and evaluations helped to improve the website’s usability, content, and user satisfaction.

While this model encourages a comprehensive evaluation of a design, it may not be feasible in all circumstances especially when time, resources and/or expertise are limited. Taylor et al. (2011) suggested the use of heuristic evaluation, along with the W3C and HON guidelines as checkpoint for accessibility, credibility, and quality of information, to evaluate health websites.

In our interface design, we analyzed the information need with the web interfaces, and studied the existing ways of information organization with home monitoring data. Although the project with the industry sponsor was completed with our deliverables as the designed web pages, and the sponsor was satisfied with the design, we felt the need of evaluating the usability through a formative evaluation. We used both cognitive walkthrough and heuristic evaluation techniques. In a recent review of four usability methods, namely, heuristic evaluation, cognitive walkthrough, pluralistic usability walkthrough, and formal usability inspections, it is generally found that heuristic evaluation and cognitive walkthrough are most commonly used methods in formative evaluation, and they have complementary advantages and disadvantages (Hollingsed & Novick, 2007).

There have been usability studies that used both methods as well (e.g., Liimatainen, 2005; Ackad, Collins, & Kay, 2010). It has been suggested that a combination of different techniques is preferred for evaluating the healthcare technologies (Jaspers, 2009). All evaluators in the study were compensated for their time.

**THE GOAL OF INFORMATION DESIGN**
The goal of information design in the project is to help an informal care provider interpret the meaning of the collected sensor data. We identified three kinds of information that should be provided in the web interfaces for achieving this goal:

- Contextual information related to the raw sensor data
  Raw sensor data are numeric without the context. To help users understand the meaning of the data, it is imperative to provide contextual information (e.g., data labels, axis labels of the sensor data graph) that is related to the collected sensor data. Examples of contextual information are data labels,

- Information that the system provides to help the users interpret the sensor data
  The sensor system can be configured to provide notification messages about specific sensor data according to the pre-set threshold values for the sensor data. To help users interpret sensor data quickly and take any necessary action, it is important to make system notification messages accessible from several places on the web site.

- Information that the senior provides to help the users interpret the sensor data
  The aforementioned information is provided by the web site and the underlying sensor system automatically. However, such information alone cannot fully interpret the home activities of a senior. For example, a lack of motion in the home for two days may be due to the fact that the senior is away from home, as opposed to an accident that has rendered the senior immobile. We considered it important to allow the senior to affect the sensor data on the web site in order to help his/her informal care providers better understand the contextual information associated with the sensor data.

**ORGANIZATION OF SENSOR DATA**
Because the sensor system provides notifications when collected data indicate potential problems with the senior, we considered it very important to provide notification messages on the home page. In presenting sensor-related
information on the home page, we considered two kinds of organization schema. The first schema organizes the information according to the purpose of each sensor, e.g., checking the water usage to determine if a faucet is left on, monitoring the fridge usage, etc. This schema was presented to us as the company’s existing web design. Because of confidentiality concerns, this web design is not presented. Essentially, the home page shows a comprehensive overview of the sensor data, and the page is divided into three main panels: the left one displays the current date and time, the right one displays notification messages generated by the system based on the pre-set threshold value for each type of sensor data, and the middle panel displays the sensor data. The middle panel has six grids such that each grid includes a graph showing a timeline view of the numeric sensor data about a sensor for a particular purpose: water usage, body motion statistics, door status, fridge usage status, blood glucose level, and blood pressure level. Although users get a comprehensive view of the sensor data on the home page, the concern was that there was too much data and information on the page, causing users to be overwhelmed.

The second schema organizes the information according to the rooms in which the sensors are installed. This is the common approach in existing sensor-based home monitoring systems, e.g., ASK-IT system’s home page as shown in Figure 1 (Bekiaris et al., 2009).

In our initial design stage, we adopted both organization mechanisms and came up with two UI designs.

USER INTERFACE DESIGN OF THE WEB
To begin the design process, we designed two information organization models and presented to the industry partner. The first design distills the data into two distinct categories, while the second design focuses on sensor location. Each design was created to simplify the information and aid user interpretation by concentrating on different elements of the data.

First Design
The organization idea behind the first design, shown in Figure 2, is similar to the one that was presented by the industry partner. The major change we made was to reduce the complication of the representation. Specifically, the home page sensor data is classified into two groups: one regarding the senior’s health condition, and the other concerning the home environment. Details of the sensor data are not available on the home page; however, the icons of the sensors will change color to indicate a warning about a set of sensor data.

Notification messages that have been issued since last time.
the informal care provider accessed the web site are displayed in the home page for quick access.

Second Design
The second design organizes the information according to the rooms in which the sensors are installed, similar to the design in (Bekiaris, 2009). We classified the sensors according to their installation locations. Figure 4 shows the home page model for the second design option. We provide notification messages on the home page instead of changing the icon color. A calendar is provided on the home page to indicate dates when the senior is not at home (e.g., a weekend visit to a friend’s place). A twitter channel is also provided to allow members post short messages.

![Figure 4. Home page of the Home Monitoring System’s Web Site for Informal Care Providers (Second Design Approach)](image)

When a user logs in to the web site, a notification message will also pop out if there is a warning, based on the sensor data collected since the last time the user was logged in. The user can also use the pop out window to browse the sensor data (see the Figure 5 above).

At a face-to-face meeting with the industry partner, we presented both designs. Our partner decided to adopt the first design approach. Additional web pages based on the first design approach were then developed. Font size, color scheme, and the use of white space between clickable items were designed to follow the convention for senior web sites (e.g., font size is at least 12 point).

FORMATIVE EVALUATION

Cognitive Walkthrough
The evaluative technique of Cognitive Walkthrough was originally introduced in (Lewis & Polson, 1990; Lewis, Polson, Wharton, & Rieman, 1990). In this method, an expert takes on the role of a defined type of user (Rubin, 1994). A task or tasks that would be typical of the interface is established and then carried out by the expert. The purpose of a cognitive walkthrough is to interactively evaluate whether the given tasks can be easily, successfully, and efficiently completed using the designed interface. Based on the process of completing different tasks, a cognitive walkthrough can identify elements of the interface and indicate areas where the users are likely to encounter problems (Sears, 1997). In these evaluations, “differences between the user’s expectations and the use reality (i.e., the navigational steps required by the interface)” are made apparent (Mahatody et al., 2010: 742), and can then be addressed and fixed (Blackmon, Kitajima, & Polson, 2003). The design of the interface is considered to be good when the purpose underlying the tasks will cause the user to engage in the appropriate actions (Wharton et al., 1994).

The cognitive walkthrough technique has been widely accepted and used in research across a range of HCI work (Hollingsed & Novick, 2007; Holzinger, 2005; Bertelsen, 2004). In particular, this approach is established with regards to researching a variety of healthcare related technologies, interfaces and applications. These appraisals include assessing home-based medical information technologies (Kaufman et al, 2003), diabetes telemedicine systems (Kaufman et al., 2003a), health information websites (Williams, Nicholas, Huntington, & McLean, 2002), and virtual wellness assistants (Ahamed, Haque, Stamm, & Kahn, 2007).

Evaluators
To conduct a cognitive walkthrough evaluation for this design, evaluators with backgrounds in cognitive psychology, web design, and/or usability testing were recruited. Four evaluators have a Bachelor’s degree in Psychology with also being a recent graduate student in Psychology. Four evaluators were in MLIS program and have taken user experience research course. One evaluator also had six years of web design working experience.

Procedure
The sessions were conducted in an individual setting, i.e., the evaluators evaluated the design separately. After the
evaluator gave consent to participate in the study, the researcher briefly explained the requirements that the evaluator needed to perform an adequate evaluation. The researcher then gave a short demonstration of a cognitive walkthrough evaluation on a shopping website (www.shop.com).

After the demonstration, the evaluator was asked to practice verbalizing thought processes by evaluating the ticket purchasing feature on www.greyhound.ca.

Once the evaluator completed the practice, the researcher opened up the interface and performed a “get it” test with the evaluators. The purpose of the test was to ensure that the evaluator knew what the interface was for and that he/she felt confident about basic navigation.

When the evaluator was ready to proceed to key tasks, the researcher read the user description and user scenario to the evaluator. Table 1 lists the tasks used in the evaluation. At each task, the evaluator had to evaluate: 1. Will the user know what to do? 2. If the user is doing the right thing, will she know she did the right thing and is making progress toward her goal? During the evaluation, the evaluator was required to verbalize every thought and action during the tasks. When the evaluator appeared to be stuck or lost, the researcher allowed some time for exploration before giving a hint. If the evaluator still could not solve the problem with the given hint, then the researcher pointed out the correct action.

At the end of Task #5, the evaluator was encouraged to leave additional comments about the design and fill out a questionnaire. The time it took to complete a cognitive walkthrough session ranged from 16 to 30 minutes, with average being 23 minutes.

<table>
<thead>
<tr>
<th>Types of Tasks</th>
<th>Task</th>
<th>Possible Correct Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Searching</td>
<td>Task #1: It has been five hours since Samantha last checked on her mother’s condition, so she opens the web interface to check to see if there were any alerts.</td>
<td>Click on “Notices”</td>
</tr>
</tbody>
</table>
|                                 | Task #2: Samantha wants to check Jane’s body movements and water usage over the past five hours. | Route 1: On home page, directly click on “Body Movement” and then click on “Water Usage” as appears on Sensor Data page  
Route 2: Click on “Sensor Data” page, click on “Body Motion” and “Water Usage” for detail. |
| Information Searching and Changing Web Content | Task #3: Samantha feels that it is important to add a water usage sensor in Jane’s bathroom. After the sensor is installed, she adds it onto the web interface. | Click on “Settings” and then click on “Add Sensor and/or Edit Current Sensors’ Information”. |
|                                 | Task #4: This system allows a user to adjust the sensitivity threshold for each sensor. After adding the new sensor to the online monitoring system, Samantha wants to review the sensitivity threshold rules for all the existing sensors, and establish one for the new sensor. | Route 1: Click on “Decision Rules”.  
Route 2: Click on “Sensor Data”.  
Click on “Adjust Sensitivity” under each graph. |
|                                 | Task #5: Samantha remembers that on Friday, her mother will be going out to visit her friend Donna down the street for the weekend. In order to prevent false alarms, Samantha makes adjustments to the sensors for that weekend. | Click on “Leaving/Visiting Rules”. |

Table 1 Task Information in Cognitive Walkthrough

Findings

Results from the questionnaires showed that the evaluators were generally satisfied and somewhat satisfied with the appearance appeal of the design and considered the web to be manageable and somewhat manageable for the tasks (except one evaluator who rated it “5” (very satisfied). During the cognitive walkthrough, the evaluators praised the simple and clean design of the interface, the easy access to the main menus on the home page (e.g. “Home”, “Sensor Data”), the straightforward navigational steps for adding a sensor, and the clearly defined sensors.

At the same time, the evaluators pointed out areas that were problematic. They indicated that the terms used in the top right menu (the Admin/Advanced Settings menus) were ambiguous and unconventional, and that the separation of “Settings” and “Adjust Sensitivity” into two different places was confusing. Furthermore, the evaluators criticized that the labels were unclear, the font size was small, and the color coding lacked legends. We discuss the identified problems in more details below.

Mental model on grouping
Our results indicated that participants had different mental model and expectations for the home page design than the design that was developed. Although the sensors were organized into groups such as home and health to allow simple sensor data retrieval, participants expected these links to also perform management functions. Consequently, four out of five participants erroneously clicked on the “Water Usage” link to try to add a sensor in Task #3. Such interactions may implicate that participants saw these big bolded links as the main control station for each type of sensors, especially when these links were their initial point of navigation. This provoked considerations for seniors and/or users who are less familiar with computer technologies; our design required the users to click away from the home page to perform management actions, but such a requirement could be jarring or confusing to these users. Therefore, it may be more convenient if there were more access points to the same function (taking advantage of redundancy) or have all important management functions on the home page, which they presumably encounter most and likely are more familiar with.

The choices of labels and the “Blood glucose” icon
The industry partner provided specific terms for the interface and we were instructed to use them. However, as the results of the cognitive walkthrough indicated, our evaluators had major concerns about these terms. None of the evaluators considered the link “Decision Rules” to be a place for viewing and changing sensitivity thresholds of the sensors. Four of them attempted “Settings” and “System Parameters” first before they decided to use “Adjust Sensitivity” on the “Sensor Data” page. The “Leaving/Visiting Rules” label was also indicated by the evaluators as a poor choice of term for the scenario of changing the sensor setting to reflect a planned absence in the apartment (as exemplified by Task #5). Because of the ambiguity of the “Leaving/Visiting Rules” label, the evaluators elected to explore the “Settings” link as they thought this might be the place for changing sensor setting. When they were asked what the terms “Decision Rules” and “Leaving/Visiting Rules” meant to them, each evaluator explained them with a different meaning. For “Decision Rules”, one evaluator perceived it as rules for using the website, and another evaluator thought “Leaving/Visiting Rules” as rules for visiting Jane. From their multiple attempts to use the “Settings” link, it seems that not only was the choice of terms inadequate but the location was also problematic. This issue requires significant attention because misunderstanding or neglect of information due to non-intuitive/confusing wording could lead to mismanagement and affect the well-being of the person in need of care.

On the home page, each type of sensors has a specific icon design, and an icon changes color from green to red to indicate an alert. The change of colors to indicate danger is a conventional idea but it appears to be problematic when combined with the icons in this particular interface. Specifically, all evaluators criticized the “Blood glucose” icon, which appeared red and indicated danger on the prototype, because the icon did not draw their attention. This caused the evaluators to neglect it as an alert. Importantly, three evaluators emphatically commented that they thought the icon was red because “blood is red”. Hence, the combined use of a blood droplet image and the color red did not convey the meaning of danger in this case and rendered the notification feature ineffective. Furthermore, the evaluators criticized that there was a lack of legend to explain the meanings of the different colors. Finally, one evaluator pointed out that the use of colors to signify alerts could be problematic for color-blind users.

Consistency of the notification mechanism
The evaluators were very critical of the inconsistencies in alert displays and labels. First, there are two types of alert displays on the home page. While alerts are indicated through differently colored icons beside the sensor links, the section beneath the two groups of sensors, which has the title “Sensors”, shows alerts by different colored dots. One evaluator suggested displaying the alerts using either the simple colored dots or icons with changing colors, but not both. Second, two evaluators commented that since “Sensors” and “Notices” mean alerts, they should use the same label. In particular, one of the evaluators suggested that instead of the extra effort to click on the “Notices” tab to find out notification details, it would be more convenient to have them directly on the home page. Additionally, another evaluator proposed bigger symbols or a “ticker bar” on the home page to make the alerts more prominent. Altogether, the evaluators’ criticisms and suggestions showed that keeping labels simple, consistent, and prominent is crucial for this tool. Elaborate designs are distracting, and could cause confusion, defeating the purpose of a notification system.

Web page layout, background color, and font size
All evaluators criticized the location of the top right menu (“Decision Rules”, “Leaving/Visiting Rules”, “Notification Recipients”, and “Social”) being hidden relative to the main contents in the center of the page. As a result, some of the evaluators did not notice it until it was pointed out to them. The small font size and black background also contributed to the problem. One evaluator was concerned that the black background may blend in with the different themes of customizable web browsers such as Mozilla Firefox. Problems with the aesthetics of the website can be easily adjusted. On the other hand, although the selection of font size on this website was made according to literature about senior users and web design, the issue presented here warrants further investigation into the literature.

Heuristic Evaluation
Heuristic Evaluation is a usability engineering method developed by Nielsen and Molich that was first introduced in (Molich & Nielsen, 1990; Nielsen & Molich, 1990). It uses a small set of evaluators, or experts, to examine an interface and evaluate its usability. Different from the
cognitive walkthrough method, it asks evaluators to critique the UI according to a specific set of heuristics or principles. Nielsen developed Ten Usability Heuristics as the basis for these principles. These heuristics include: visibility of system status; match between system and real world; user control and freedom; consistency and standards; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; help users recognize, diagnose, and recover from errors; and help and documentation (Nielsen, 1994).

Heuristic evaluation technique has also been widely used to examine usability of various systems, such as Personal Health Record system (Liu, Shih, & Hayes, 2011), digital libraries (Liu & Zhang, 2009), and Institutional repositories (Kim, 2005).

Heuristics Checklist
The checklist for this evaluation was adapted from a comprehensive list called A Heuristic Evaluation - A Systems Checklist (Periotti, 2012). Specifically, the heuristics considered in our study include: visibility of systems status; match between system and the real world; user control and freedom; consistency and standards; recognition rather than recall; aesthetic and minimalist design; help and documentation; and privacy. Although privacy is not one of Nielsen’s heuristics, it was included in this evaluation due to the nature of the web interface as a monitoring system.

Evaluators
According to Nielsen and Molich (1990), the optimal number of evaluators is three to five. They state that five evaluators will find at least 85% of usability problems. As such, this evaluation used five evaluators in order to gather the best possible data. These evaluators were defined as individuals with an adequate level of experience in web usability. Four of them have taken MLIS courses on User Experience Research and Information Visualization. Also, four have significant experiences in web site creation and design. One evaluator has extensive experiences in instructing courses on digital libraries and web usability. One evaluator has experiences in guiding seniors through computer systems and web interfaces in a library setting, and the usability problems that can occur.

Procedure
Each session was conducted individually, and the evaluators assessed the design separately. After a brief overview of the web site, (e.g., the purpose of the site, the intended users, and the current stage of the design) the evaluators were provided with the checklist to complete the evaluation. Each session lasted approximate 30 to 45 minutes. The evaluators were also encouraged to think aloud during the process while the researcher took notes.

Following the evaluation session, the evaluators also participated in a brief interview regarding their feedback on the design of the web interface, e.g., what was your overall impression of the web interface? What were the most serious issues you identified? Why do you think these are the most serious? The researcher also asked for their suggestions on improvement.

Finding
In addition to detecting usability issues, each evaluator was also asked to assign a severity rating to each identified issue. The results were then categorized according to various features of each page, and arranged based on severity rating. As an example, table 2 presents the severity rating for home page’s features.

<table>
<thead>
<tr>
<th>ISSUE IDENTIFIED / COMMENTS</th>
<th>SEVERITY RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>New notifications should be present on the home page</td>
<td>High</td>
</tr>
<tr>
<td>Notifications should be first thing seen - they could be present on an additional sidebar or in the existing sidebar</td>
<td>High</td>
</tr>
<tr>
<td>Icons should be visibly different when selected</td>
<td>Medium</td>
</tr>
<tr>
<td>The term home is used for two different functions - home page and home environment. One of these terms should be changed to prevent confusion (e.g. Home Page changed to “Main”)</td>
<td>Medium</td>
</tr>
<tr>
<td>Health/body related icons should be distinguished from environment icons (e.g. all not, instead of just blood glucose)</td>
<td>Low</td>
</tr>
<tr>
<td>More could be done to make icons distinct</td>
<td>Low</td>
</tr>
<tr>
<td>Fridge and door icons are very similar</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2 Evaluators’ Severity Rating on Identified Issues for the Home Page

Overall, high severity issues can be distilled into two broad concerns: notifications and the lack of help and support throughout the web interface. Almost every evaluator identified issues surrounding these two categories, and these issues were consistently given a high severity rating. As such, the debriefing interviews often focused especially on these concerns. We discuss these two issues in more details below.

Notification Issues
During the debriefing interview, four out of five evaluators were concerned that notices that needed immediate attention were not prominently displayed on the home page. It was also not recognized that the red icon is intended to indicate a warning. Most evaluators assumed that the color was intended to identify the icon as a blood drop, rather than to signify that there is a sensor warning. This was reinforced by one suggestion that the health icons should all be in red, in order to create a distinction from the environment icons. As such, it was concluded that using the icon color is not an apparent or obvious manner to convey a new notification, especially for icons related to blood.

Evaluators also indicated that the selection label ‘Notices’ was misleading, as the page is actually intended to be a history of notifications. Evaluators assumed, and surmised that users would likely also assume, that this page would contain notices that require immediate attention rather than a history page. They also noted that the label is inconsistent
with the page title of 'Notification History', which is a more appropriate label. Evaluators who noted this specific inconsistency issue rated it with high severity, unlike other consistency issues which received lower severity ratings. This signifies that notifications and notices are considered a highly important element in the monitoring interface. As one evaluator said in their interview, "The main function of the site is to monitor - if it doesn't adequately give notices and warnings, there's no point in monitoring." Therefore, issues concerning the notices and notifications were considered the most important and severe issues, particularly when the health and safety of a senior is dependent on the system.

Lack of Instruction, Help and Support Issues
In addition to the absence of visible notice and alerts, evaluators also noticed a lack of help and support throughout the interface. This issue was most observable in situations where a user is required to input data and make selections. Evaluators noted that there were no instructions as to how to achieve these tasks. It was noted that instruction is necessary on the notifications history page, as there is no clear indication that confirmation data can be inputted into fields in this screen, or which fields are required. One evaluator observed that since none of the fields are indicated as 'required', a user would assume all fields are necessary. However, the blank confirmation fields in the prototype indicate that this is false, and some fields are optional. This observation signifies that instruction and support are required to guide a user through the interface in order for him or her to use it effectively, and to know exactly how to input data appropriately.

In contrast to high severity issues, medium severity issues can mostly be categorized as concerns that relate to the navigation of the site. These include issues such as: selection labels; inconsistencies with place indicators; page titles; and reverse options such as a 'back' button. These issues preclude a user from smoothly navigating around the site and accessing all desired information.

Low severity issues can primarily be categorized as cosmetic issues that do not affect the functionality of the interface or significantly hinder its usage. These concerns include issues such as: excessive white space on the settings page; small, 'hard to read' text; color choices; and icon usage and color. However, these issues are only given a low priority when not related to notices and warnings, which reinforces the opinion of evaluators concerning issues to do with notifications and high severity.

Privacy Issues
Although the majority of evaluators expressed discomfort with the concept of the interface, opinions on privacy issues were evenly distributed. While some evaluators remarked that a lack of privacy was to be expected in the context of the site, they expressed doubt as to whether a senior would willingly agree to be monitored in such a fashion. Other evaluators noted that a system such as this might be necessary for a senior who wishes to live independently. (According to Hensel, Skubic, and Rantz’ focus group study (2008) with seniors in a retirement community, they found that there was an overall positive attitude toward sensor-based home monitoring systems. Some participants did express concerns about privacy issues, but indicated that they would allow others to monitor their daily activities if the technologies could enhance their safety and wellbeing.

LESSONS LEARNT
Both cognitive walkthrough and heuristic evaluation methods identified notification mechanisms need to be redesigned. The notification mechanisms need to bring immediate attention to the users in a better and more effective way. The redesign needs to clearly separate the two kinds of notification information on the home page: health- and home-related information, and sensor condition information. Although the design we presented to the evaluator had example notification messages on the home page, they were about the sensors' conditions (e.g., a sensor is low on battery). Furthermore, it was considered a poor design choice to color code the sensors' icons to signal warnings.

Due to the time constraint, we did not conduct formative evaluations when we presented both designs to the company. Instead, we only presented two designs to the industry sponsor and explained the pros and cons for each and the potential issues related to the color-coding and notification mechanisms in the first design. However, the company chose the first design over the second design despite of the foreseen issues. Considering that the company provided partial funding for this project and the need to respect stakeholder’s opinions, we abandoned the second design approach and quickly developed a prototype for formative evaluation.

We speculated that the second design would have been a better option because it would give the user a pop-up with warning messages when he/she logs in. This is the kind of prominent, attention-grabbing notification mechanism that our evaluators had suggested in one way or another during the evaluation. We also think that if we had conducted evaluations before the presentation and showed the results to the company, it may have changed its preference and chose the second design option. Therefore, our first lesson learnt is that even with the time constraint, it is still very important to present the design options along with their formative evaluations results, instead of just presenting the designs and the design rationales (i.e., pros and cons of each design feature). For future partnership projects with companies, we will use this case to illustrate the importance of allocating time for formative evaluation even at the very early stage of the design process.

In heuristic evaluation, the most notable effect of an evaluator’s background was not their experience with usability principles, but with evaluation methods. While all
evaluators possessed adequate experience with web usability to identify potential issues, the evaluator that was not as familiar with evaluation methods provided data that suggested user testing rather than identifying issues. This indicates that a sound understanding of an evaluator’s role in the process is just as crucial as an understanding of web usability to generate the most optimal data in a heuristic evaluation.

The third lesson we learnt is the necessity of combining multiple inspection methods to gain better coverage of usability issues. Although the two evaluation methods identified major usability issues like notification mechanism, consistency problem, background and layout, etc., there are important issues that were only noticed in one method. For example, heuristic evaluation raised privacy concerns of using the interfaces and the lack of user support in the design. These were not mentioned in cognitive walkthrough. And the grouping problem with the home page’s sensor classification was a consistent theme in cognitive walkthrough, but not recognized in heuristic evaluation. Related to navigating through the web site and retrieving the information, all these issues are critical to the usability of the web site. The privacy issue directly affects the users’ adoption rate of such system and the web site. Our study certainly is another case study example that shows the importance and benefits of combining two or more evaluation methods in early design.

CONCLUSION

The phenomenon of increasing number of seniors opting to live on their own could brings varieties of issues such as social isolation and home emergencies due to their faltering health conditions. As an attempt to fulfill these seniors’ wish to live independently and ease anxiety of care providers, many home monitoring systems have been developed both in academia and in industry to provide these a safe and well-connected living environment for seniors. In the current project, a Canada-based company collaborated with a national research lab developed a sensor-based home monitoring system, and our role was to create web interfaces for users.

Our project’s goal was to build a user-friendly web environment that provides meaningful information to the informal care providers of independently living seniors. In conceptualizing the user interface, we identified three kinds of information that would be useful to users: contextual information related to the raw sensor data, system information to help interpret the sensor data, and additional information input by the seniors to aid overall data interpretation. The organization schema in the interface goes according to the purpose of each sensor.

After a prototype was built, the cognitive walkthrough method and the heuristic evaluation were used for formative evaluation. Common problems were discovered in both methods such as problematic notification mechanism, inconsistency, background and layout. However, some specific problems were identified only in one method but not the other due to differences in the nature of methodology. Specifically, grouping problem was found through the interactive tasks in the cognitive walkthrough, and privacy concerns and lack of user support were found by evaluating against a checklist in the heuristic evaluation.

It has been recognized that technologies can play a big role in health information management. However, for these technologies to be effective, they must be accessible and meet users’ expectations. Results from the two evaluation methods provided meaningful insights into the pros and cons of health-related technologies. Furthermore, the study helps researchers of health-related technologies to determine which method to use. Although it is highly recommended to combine them as they have complementary advantages and disadvantages.

The experiences in this study helped us reflect on approaches and strategies when working with industry partners. Even under the time constraint, we should not underestimate the value of conducting the formative evaluation before presenting the design to the industry partner. To help the company make the right design selection decision, we should present not only design rationales and our preferences, but also results from the formative evaluation.

ACKNOWLEDGMENTS

We would like to thank Valentin Kelemen, Dave Gallant, and Jennifer Martin for their contribution on the web page design in the project. The project is sponsored by NSERC Engage program (EGP #417500) and the industry partner.

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