Icon Design for User Interface of Remote Patient Monitoring Mobile Devices

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ABSTRACT
The purpose of this paper is to describe the studies undertaken in order to improve and simplify user interface (UI) design of a Remote Patient Monitoring (RPM) device, specifically the BL Healthcare Access Tablet. Current icon designs for UIs of the RPM devices are not well designed to reflect the needs, experiences and limitations of the end-user. Complex and unclear UIs and instructions make compliance with self-management schedules often poor. The issue of compliance, with the need for effective communication between chronic disease patients and healthcare professionals emphasize the need for the appropriate UI and communication technology. Improvement is made from the perspective of the user experience (UX) / UI redesign. Usability studies were conducted, followed by the UI redesign and icons design with the aim to address the UX design. A mobile application concept for the RPM is developed, that could be used on existing tablets and smartphones, thus eliminating the need for the current costly hardware.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – Graphical user interfaces (GUI).

Keywords
Icons design, interaction design, remote patient monitoring, telehealth, user experience, user interface.

1. INTRODUCTION
Remote Patient Monitoring (RPM), as one of the telehealth care modes [1], is a home-based monitoring system to support patients with chronic conditions [2]. It is proven to be useful to homebound older adults who have difficulty in accessing care due to disability, transportation, or isolation, effectively engaging them in self-care disease management [2]. RPM is effective technology for recording and storing patient data, such as vital signs or symptoms [3]. Data from the medical peripherals are sent via Bluetooth onto the home monitoring devices and transmitted to health care professionals for review. The opinion from the health care provider is then sent back to the RPM device.

Chronic disease patients are personally responsible for their daily care. They must actively participate in their treatment in order to achieve effective management of chronic diseases [3]. However, due to complex and unclear UIs and instructions, compliance with daily self-management plans is not adequate [4], [5]. One of the problems that can make older adults experience dissatisfaction while using technology is usability. Several studies reported that certain fonts are difficult to read, metaphors and icons difficult to be interpreted, and that memory and motor problems can make it hard to operate a system [6].

Although information technology (IT) integration in the medical field has increased during the past decade, UI design was not optimized [7]. Usability testing was not required for UI design of the health IT systems [7].

Usability needs to be assessed when designing for older adults, taking into an account choice of the icons, fonts, and font sizes [6]. Successful implementation of RPM requires easy to use devices with good UI design. A good UI design is intuitive, easy to use, and inexpensive to maintain, to support, and to train the users [8]. It can lead to safe and effective equipment operation, installation, and maintenance [9]. In order to deliver good UI design, human factors should be considered early in the design process, and user testing should be conducted throughout the whole design process involving participants from the end-user population [9].

The purpose of this paper is to describe the studies undertaken in order to improve and simplify UI design of RPM devices, specifically the BL Healthcare Access Tablet. Concern over health risks due to non-compliance with self-management schedules is addressed in this case study by the UX/UI redesign and icon design. Following this line of work, there is a need to...
develop easier to use and improved UI of the RPM devices. This paper describes UI redesign, usability studies, and icon design for the proposed RPM mobile application concept, which could be used on existing tablets and smartphones.

2. BACKGROUND
RPM technology addresses the needs of older adults in efficient and effective way, and helps in facilitating greater independence of older adults [4]. “People want to take a more active role in managing their health care - both to reduce costs and improve their quality of life,” said Katherine Holland, general manager of IBM Life Sciences [5] (p.28-34).

Current market solutions for RPM are stationary hubs that connect via Bluetooth with medical peripheral devices. RPM hubs take and record health-related readings, send data to the server, making those accessible to the healthcare providers.

According to the study “Wearable Dry Sensors with Bluetooth Connection for Use in Remote Patient Monitoring System” [6], RPM devices have many design requirements with portability being one of the most important ones.

Mobile computing poses a series of challenges for UI design and development. UIs must now accommodate the capabilities of various access devices, in this case tablets, smartphones, and medical peripheral devices. In addition to this, UIs need to be suitable for different contexts of use, while preserving consistency and usability [7]. RPM mobile application UI needs to accommodate use on both the tablets and the smartphones.

Older adults have a specific relationship with technology. This mostly comes from the fact that hardware and software have not been designed to suit their needs [8]. They are considered a market niche for the sales of RPM technology products [9]. Technology through RPM supports physical independence and stimulates social and psychological engagement. It is important to share with machines a common language in order to naturally interact with them [10]. Furthermore, Norman [10] brings up that technologies are not capable to adapt their language to different classes of humans, unless they are designed to do so.

Familiarity of the technology language to tell about its usage, objectives and meanings, covering issues of usability, accessibility, accountability, and acceptability has a great importance in the communication between older adults and technology [9]. Also, perception of high benefits associated with the adoption of technology is valuable motivation for older adults to accept perceived costs and effort associated with using a technology [11].

Icons designed for usability improve the user experience of an UI [4]. Usable icons need to be clear and legible, simple, consistent, and familiar [12]. They should enhance recognition, be meaningful, and hasten option selection [12]. Choice of the color and type improve instruction [13]. An important principle of good icon design is to always provide a text label [12].

As discussed by Bernard, older adults prefer larger font sizes and sans serif fonts over serif fonts [14] [15]. In a study by Bernard, Liao, and Mills [15], serif fonts (Georgia and Times New Roman) were compared to sans serif fonts (Arial and Verdana) at 12- and 14-points. Overall findings resulted in older adults’ preference for the 14-point fonts that promoted faster reading and were found more legible. The sans serif fonts were more preferred than the serif fonts. Sorg [16] found that older adults preferred to read sans serif font Helvetica, compared to serif font Century Schoolbook.

Usability testing requires relatively small test groups [12]. Nielsen [17] states that “elaborate usability tests are a waste of resources. The best results come from testing no more than 5 users and running as many small tests as you can afford.” When dealing with homogeneous group of users, observing five users can identify a high percentage of the most critical errors [17]. For efficient and productive usability testing five is the optimal number of users [17-19]. Usability testing with more than five users is proven to be waste of time and money, which could be spent on assessment of design changes [12] and more tests.

3. PURPOSE OF THE STUDY
3.1 Design Criteria

- Design RPM customizable mobile application concept that could be used on existing tablets and smartphones,
- Design simple and clear icons for UI,
- Design icons that are easy to be interpreted by the older adults,
- Have bigger graphics and font sizes for both smartphone and tablet,
- Choose fonts that are easy to read by the older adults.

The sign of this study is advancement of new designs of RPM devices by developing RPM mobile application concept that could be used on existing tablets and smartphones, thus eliminating the need for costly hub units. Portability provides chronic disease patients with the advantage to get medical advice and send vital sign measurements from any place, integrating RPM into their daily lives. Additional benefit to the patients is that “convergence with consumer electronic products will enable patients to use devices they are already familiar and comfortable with” [20].

3.2 The BL Healthcare Access Tablet

A case study was undertaken with the BL Healthcare Access Tablet, as one of the RPM devices that are widely adopted on the market. The BL Healthcare Access Tablet UI provides various applications that could be accessed form the home screen (See Figure 1). Vital signs monitoring is the main function that provides connection with medical peripheral devices. Charts function visualizes vital signs data. Setting up the sessions and messaging with the healthcare provider are two functions that provide communication with the healthcare professionals. In addition to this, there are a few other wellness and education-related functions like the Workout Tracker and Medical Terms.

![Figure 1. Graphic UI of the BL Healthcare Access Tablet.](image)

4. METHODOLOGY

The icon design study was organized into three phases: 1 – User Experience, 2 – Evaluation / Testing, and 3 – Concept Refinement.
4.1 Phase 1 – User Experience
The purpose of the phase 1 was to improve the UX of The BL Healthcare Access Tablet with the goal of improving its icon design for UI, by conducting usability studies. Specific goals included:

- Usability Testing 1: one hour-long observation with the group of older adults testing the UI of the chosen RPM device,
- Usability Report 1: analysis of the results retrieved from the observation, and
- Icon Redesign: application of the results to the RPM device icon redesign; initial concepts development.

Usability Testing 1 was conducted with six volunteers from a local Naturally Occurring Retirement Community (NORC). One-hour-long observation was performed with each volunteer individually, followed by an interview. Volunteers were asked to perform task of using the Sleep Journal UI of The BL Healthcare Access Tablet, on both the iPhone and the iPad. The Sleep Journal function was chosen for the testing purposes because of the important relationship between the sleep quality of the older adults and their chronic conditions [21]. Daily task of conducting the sleep quality survey is reported this way. The tasks were video recorded.

List of the interview questions was presented to the volunteers. Navigation through the Sleep Journal UI, level of satisfaction, and visual interface were tested during the interview. Screen size management and differences, including the ease of use, were tested using both the iPhone and the iPad. Comments on differences and screen size preferences were taken in the overall impressions section.

For the first list of questions volunteers were given the five-point Likert scale (Very easy, Easy, Neutral, Difficult, and Very difficult or Excellent, Good, Neutral, Not so good, and Not good at all). The questions regarding the satisfaction with the RPM mobile application had the following answers: Very satisfied, Satisfied, Neutral, Dissatisfied, and Very dissatisfied.

Icon redesign for UI followed the Usability Report 1 with various designs of visuals (icons, color coordination, and button sizes). Exploration of different icons for text buttons representing different functions of the RPM mobile application took place during this phase. Three sets of icons for the buttons were designed for the following functions of the mobile application: video call, charts, messages, settings, sleep journal, contacts, and sessions.

4.2 Phase 2 – Evaluation / Testing
Phase 2 was dedicated to the evaluation of the improved icon concepts by conducting additional usability testing with the purpose of choosing the final concept. Specific goals included:

- Usability Testing 2: one hour-long observation with the same group of older adults testing the improved icon concepts on the smartphone.
- Usability Report 2: Analysis of the observation and choosing the final concept.

Usability Testing 2 was conducted with five out of six volunteers from the Usability Testing 1. It took place at the same Naturally Occurring Retirement Community (NORC). One-hour-long observation was performed with each volunteer individually, followed by an interview. Volunteers were asked to perform task of using the mockup UI on the iPhone. HTML with JQuery Mobile mockup was made for the purpose of this usability testing.

Mockup application had all the functions of the RPM mobile application:

- Charts, as the main function of visualizing and recording the body vital measurements,
- “Alert” button, which calls 911 in a case of emergency (in the case of this mockup personal number was used),
- Video call, including the voice call option (the same personal number was used for the mockup version),
- Sleep Journal, daily survey of the patient’s sleep quality (survey question pages were designed),
- Messages, providing the health-related messaging (in the case of a mockup the first page was designed),
- Sessions, allowing for scheduling the check-ups and visits to the doctor’s office (scheduling the checkup by inserting name and date preferred),
- Contacts (Contacts sample page was designed),
- Settings, which provides for customization based on the chronic condition, personalization based on the user’s preferences, and medicine reminder (Settings sample page was designed).

Volunteers were asked to go through the task of using all the functions on the home screen (video call, charts, messages, settings, sleep journal, contacts, and sessions) and the “Alert” button. Observation was video recorded.

The goal of the second usability study was to test the icon design for UI and interaction design with the mockup mobile application concept including: navigation through the UI, visual interface including its icons, colors, sizes, shapes, and graphics, screen size management, level of satisfaction, information inclusion, ease of use, and overall impressions.

List of the interview questions was presented to the volunteers. The same list of questions used during the Usability Testing 1 was used for the Usability Testing 2. For the first list of questions volunteers were given the 5-point Likert scale. The same criteria was used as the one in the Usability Testing 1. Interview continued with the same list of open-ended questions used for the purpose of the Usability Testing 2, asking for their overall thoughts on device itself.

In addition to that, three sets of icons for the home screen buttons were tested. Volunteers were asked to associate each function of the RPM mobile application concept with one of the three icons. The goal of this task was to find the icon that potential users associate the best with the given function. All the functions (video call, charts, messages, settings, sleep journal, contacts, and sessions) were available on the mockup home screen.

4.3 Phase 3 – Concept Refinement
Phase 3 consisted of the final concept development. Final icon concept was designed based on the results of the Usability Report 2. Concept refinement consisted of the following phases:

- Design of the icons with the color coordination,
- Choosing the right font and font size,
- Peer Review,
- Prioritizing the functions of the RPM mobile application,
- Future design considerations.

The final concept development started with designing the icons for the Home Screen buttons that represented each of the
functions RPM mobile application provided. It continued with choosing the right font and font size for the functions of the mobile application. Different icons for all the functions were designed and tested in a Peer Review with a group of five volunteers that were considered experts in the field, with the goal of choosing the most adequate one for each of the functions. Color-coordination for the icons and fonts for the functions were also tested here.

5. RESULTS

5.1 User Experience

5.1.1 Usability Testing 1

The goal of the usability testing was to test navigation through the Sleep Journal UI, visual interface (icons, colors, sizes, shapes, and graphics), screen size management, information inclusion, ease of use, and subjective satisfaction with UI of The BL Healthcare Access Tablet’s Sleep Journal.

5.2.1 Usability Report 1

Usability Report 1 summarized all the results of the Usability Study 1 (See Graph 1). Satisfaction with the UI, icons, colors, size, shapes, and graphic, as well as the ease of use and navigation through the UI were rated as excellent by all the volunteers. The executive summary reported that all volunteers had an issue with the touchscreen navigation of both the iPhone and the iPad. Problems included increasing the size of the screen unintentionally when tapping.

One volunteer had a negative comment on the screen size: “Small size is not good for eyes.” This volunteer would have used the iPhone when needed outside the house. The other volunteer wanted to have bigger size of the scale graphics on the iPhone.

HTML5 with jQuery Mobile was used to develop the prototype of the RPM mobile application for the purpose of the Usability Testing 2. The prototype had a log in page, the Home Screen with all the functions of the RPM mobile application (video call, charts, messages, settings, sleep journal, contacts, and sessions), the first page of all the functions of the application, and three pages of the Sleep Journal function.

5.2 Evaluation / Testing

5.2.1 Usability Testing 2

Goal of the usability testing was to test navigation through the UI, visual interface (icons, colors, sizes, shapes, and graphics), screen size management, information inclusion, ease of use, and subjective satisfaction with the RPM mobile application UI.

In addition to this, three sets of icon designs were tested and associated with words representing the functions of the RPM mobile application (video call, charts, messages, settings, sleep journal, contacts, and sessions), with the goal of choosing the most adequate ones for the final concept development.

5.2.2 Usability Report 2

Usability Report 2 summarized all the finding from the Usability Study 2. Executive summary included results of the interview questions presented in the Graph 2.
Results of the icons testing can be found in the Table 1 (V was used for the term volunteer). Volunteers of the Usability Testing 2 associated word “Chart” with the icon that had the image of the chart. Word “Contacts” was associated with the image of the address book. Volunteers associated word “Messages” with the word cloud with smiley face. “Sessions” was associated with the icon of the professional, while “Settings” was connected with the gears. Cloud with letters Z that writes represented the “Sleep Journal”, and camera was associated with the “Video Call”.

<table>
<thead>
<tr>
<th>Functions</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
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<tbody>
<tr>
<td>Charts</td>
<td>3</td>
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<tr>
<td>Contacts</td>
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<tr>
<td>Messages</td>
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<td>Sessions</td>
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<td>Settings</td>
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<tr>
<td>Sleep Journal</td>
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<tr>
<td>Video Call</td>
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</table>

Icons that were associated with the functions of the mobile application the most are presented in a Figure 3.

![Figure 3. Icons That Were Associated the Most With the Functions of the RPM Mobile Application.](image)

### 5.3 Concept Refinement

#### 5.3.1 Peer Review

Choice of fonts was determined based on the results of the research and the Peer Review with a group of five volunteers that were considered experts in the field. Research reported that older adults prefer larger font sizes, specifically 14-point font size. They also prefer sans serif fonts over serif fonts [14]. Choice of the following sans serif fonts was presented to the participants: Arial, Arial Rounded MT Bold, Calibri, Estrangelo Edessa, Helvetica, Mangal Bold, Raavi, Trebuchet MS, Verdana, and Vrinda (See Table 2). 14-point font size was used. Results of the peer review reported that Mangal Bold was preferred font.

<table>
<thead>
<tr>
<th>Functions</th>
<th>Charts</th>
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</table>

Based on the results of the Usability Study 2 and the Usability Report 2, icons for the RPM mobile application functions were designed. Reference colors for the icons design were black, white, and cyan. Black and white were used as contrasting colors, and cyan was used as an accent color. The order by which they were presented is the following one: Contacts, Sessions, Video Call, Charts, Messages, Sleep Journal, and Settings (See Figure 4).

The “Alert button” was designed based on the results of the Usability Testing 2. All the volunteers of the study required the “Alert button” to be prominent, spread across the whole page, and located at the top of the screen. Design of the “Alert button” explored different sizes and representations of the alert signage. It was designed as a red button, associating one with the importance of its function.

![Figure 4. Icons Concepts for the Final Concept Development.](image)

Results of the Peer Review finalized icons design for the buttons of the Home Screen that will represent all the RPM mobile application functions (See Table 3).

<table>
<thead>
<tr>
<th>Functions</th>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
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<tbody>
<tr>
<td>Contacts</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
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<tr>
<td>Sessions</td>
<td>6</td>
<td>2</td>
<td>1</td>
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<tr>
<td>Video Call</td>
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<td>Charts</td>
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<td>Messages</td>
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<tr>
<td>Sleep Journal</td>
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<td>Settings</td>
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<tr>
<td>Alarm</td>
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</table>

Color-coordination was also explored based on the Usability Study 2 findings. All the volunteers preferred bright colors and contrast. Color coordination was presented to the volunteers (See
Figure 5). Based on the results of the Peer Review, icons design was finalized. As the reference, the initial set of icons with the reference colors was placed next to the icons with different bright colors options (color coordination). Volunteers were asked to choose one of the color options for the icons.

Volunteers preferred the original choice of black, white, and cyan, and also warm color options in Video Call, Charts, Sleep Journal, and Settings.

![Figures of icons and their numbers.](image)

**Figure 5. Color Coordination for the Icons.**

Charts icons number 1 and number 4 got equal number of votes. In order to keep consistent appearance of all the icons, Chart icon number 4 was chosen for the final design (See Table 3).

<table>
<thead>
<tr>
<th>Functions</th>
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<td>Contacts</td>
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<td>Video Call</td>
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<tr>
<td>Charts</td>
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<tr>
<td>Messages</td>
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<tr>
<td>Sleep Journal</td>
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<tr>
<td>Settings</td>
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<td>Alert</td>
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</table>

Since most of the icons have cyan as a background color, cyan was chosen as the background color for the final Chart icon as well. Cyan was slightly changed into a more pleasing and more neutral color (See Figure 6).

6. CONCLUSION

6.1 Discussion

The icon design study improved the UX/UI aspect of the RPM devices, specifically The BL Healthcare Access Tablet. Its unique approach of eliminating the need for the hub unit and its manufacturing by designing customizable RPM mobile application concept led to the improvement of the whole RPM system.

Icons for UI of the RPM mobile application were simplified and adapted for the use by the older adults. Fonts that are easy to read and icons that are easy to interpret were chosen, providing easier use and greater satisfaction with the product and the service. Icons were designed to be recognizable and meaningful. In addition to this, bigger graphics and font sizes for both smartphone and tablet were chosen, to accommodate the needs of the older adults.

RPM mobile or tablet application can be used to record, visualize, and send data to the server. This way data could be accessed from the server by the healthcare provider’s office. Other RPM functions, like video conferencing, scheduled sessions, recording daily sleep journal, or medicine reminder can also be done through these devices.

The Mobile Health Application has a log-in page to allow for caregivers and patients to have separate entries to the application and provide for additional security of the data. Application has the following functions that could be accessed from the main page:

- The Alert button, which will call 911 by pressing it once in a case of emergency,
• Charts, which collect, record, and visualize various vitals such as blood pressure, weight, body temperature, blood glucose levels, etc.,
• Daily Sleep Journal, a short survey of health and sleep-related questions,
• Video call, which allows for video conferencing, virtual clinic visits, health counseling, video visits for case management, coordination of care between multiple parties, wound/skin inspection using plug-n cameras, directly observed therapy, and video conferencing with family members,
• Scheduled sessions with the healthcare provider,
• Health-related messaging,
• Contacts,
• Medicine reminder, that is incorporated into the Settings function,
• Settings, where patients can personalize their mobile application and healthcare providers can customize the application based on the chronic disease.

The Mobile Health Application is customizable for the patients with different chronic conditions. It can be personalized by the users by uploading different images and backgrounds.

UX redesign had the greatest impact on users by adding the portability to the RPM and giving them the opportunity to use the RPM mobile application outside their homes. This flexibility gives the chronic disease patients more freedom and may enhance their daily amount of physical activities, thus further benefitting their health. Additional benefit to these patients is commodity of using the devices they are already familiar and comfortable with.

6.2 Future Work

Next steps include adding other important features to the mobile application UI, with related icons. Several additional features are possible that could help in patients’ health management:
• Educational videos,
• Health-related games and readings as a part of the library,
• Social aspect of connecting with other patients.

Development of new technologies allow for advanced types of social networking for patients [22]. Social support can increase patients’ possibility for success in achieving health-related goals [22].

In addition to having more features, the case study requires future steps of conducting the additional usability studies and further refinements of the final icons concept.

7. REFERENCES

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