*MEDINFO 2015: eHealth-enabled Health*
*I.N. Sarkar et al. (Eds.)*

*doi:10.3233/978-1-61499-564-7-358*

# Evidence-based Heuristics for Evaluating Demands on eHealth Literacy and Usability in a Mobile Consumer Health Application

**Helen Monkman[a], Janessa Griffith[a], Andre W. Kushniruk[a]**

[a] *School of Health Information Science, University of Victoria, Victoria, BC, Canada*

**Abstract**

*Heuristic evaluations have proven to be valuable for identifying usability issues in systems. Commonly used sets of heuritics exist; however, they may not always be the most suitable, given the specific goal of the analysis. One such example is seeking to evaluate the demands on eHealth literacy and usability of consumer health information systems. In this study, eight essential heuristics and three optional heuristics subsumed from the evidence on eHealth/health literacy and usability were tested for their utility in assessing a mobile blood pressure tracking application (app). This evaluation revealed a variety of ways the design of the app could both benefit and impede users with limited eHealth literacy. This study demonstrated the utility of a low-cost, single evaluation approach for identifying both eHealth literacy and usability issues based on existing evidence in the literature.*

***Keywords:***

Consumer health informatics; usability; eHealth literacy; health literacy; heuristic evaluation; mHealth

## Introduction

Potential patient safety implications arise from the use of consumer health applications (apps), and consumer health information systems (HISs) more generally. As such, new strategies should be explored to identify potential problems and resolve them. To this end, the National Health Service (NHS) currently offers a "Health Apps Library" which endorses apps that are considered to a) be relevant to British people, b) provide trustworthy information, c) abide by data storage regulations, and d) not pose potential risks due to improper use [1]. The clinical assurance team, comprised of doctors, nurses and safety specialists, review apps and collaborate with app developers to ensure clinical safety standards are met before they are accepted into the Health Apps library [1]. However, the review appears to focus solely on guided user decision-making without the oversight of a healthcare professional, as the only potential clinical risk consumer HISs can generate. Although this is a promising and important new strategy, other factors may create clinical risk through the use of consumer HISs. For example, incongruence between the demand the system places on eHealth literacy and the user's actual eHealth literacy skills could result in misinterpretation of information.

Health Literacy is the "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [2]. However, technology has the potential to introduce entirely new challenges for consumer seeking health information health literacy stemming from system interactions. Emphasizing this argument, eHealth Literacy is "the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem" [3]. Moreover, it is not prudent to investigate the demand placed on eHealth literacy by a system without considering the system's usability more generally, as either factor being suboptimal may deter or prevent consumer HISs use.

Heuristic evaluation is a popular usability inspection method because it is a rapid, low-cost, investigation that often provides useful insights to improve system usability. Heuristic evaluation could be considered as a complementary and/or preliminary method of identifying potential usability issues that can be remedied before investing in more expensive and time consuming usability testing with representative users.

Although commonly used sets of heuristics (e.g., Nielsen's 10 [4]) are typically applied, these generic sets of heuristics may not always be the most suitable for a particular evaluation, user group, or system. Thus, some researchers have opted to develop their own heuristics based on the specific goal(s) of an assessment. For example, heuristics have been developed to evaluate health information system safety [5].

Another shortcoming of commonly applied sets of usability heuristics is that they predominantly focus on the analysis of the software component and neglect the system content or information presentation. It has been previously argued that special design considerations are necessary for users with limited health literacy, as they often use systems differently than more health literate users [6]. This argument led to the development of new heuristics, potentially more suitable for consumer health information systems [6]. However, a limitation of the previous work [6] is that the heuristics were generated from a single resource: *Health Literacy Online: A guide to writing and designing easy to use Web sites* [7]. Albeit composite and thorough, Health Literacy Online was published in 2010; since its publication, there has been an influx of research on eHealth/health literacy and usability. Thus, there is an opportunity to refine heuristics initially proposed by Monkman and Kushniruk [6], as well as generate new heuristics based on the recent literature.

This study will test the utility of a new set of evidence-based heuristics derived from the literature on eHealth literacy and usability. The heuristics will be used to evaluate a mobile blood pressure app to determine how using this app might benefit consumers, as well as what obstacles this app might present to users in terms of both demands on eHealth literacy and usability.

## Methods

### Heuristics and Severity Scale

Building on previous work [6], the current investigation sought to expand on the heuristics orginally proposed by the

authors, by incorporating recommendations from additional research on eHealth/health literacy and usability. Therefore, the body of literature investigating eHealth/health literacy and usability in conjunction were used to generate a novel set of heuristics. Barriers and recommendations reported in the literature were then subsumed into heuristics. This analysis identified a total of 8 essential heuristics (see Table 1) with an additional 3 heuristics relevant to specific types of content or medium that can be used dependent upon the system under investigation (see Table 2). This set of heuristics were then applied to test their utility assessing a mobile consumer health application to identify potential issues related to demands on eHealth literacy and usability.

*Table 1– Evidence-Based Heuristics for Health Literacy and Usability*

| | Heuristic | Description |
|---|---|---|
| 1. | **Immediately Inform Users of Purpose and Engage Users, Avoid Registration** | Identify the purpose and audience on the home screen/page. If unavoidable, make registration and logging in simple and obvious. |
| 2. | **Use Complementary Interaction Methods** | Make use of alternative inputs (e.g., touch screen, barcode scanning, voice commands) and outputs (e.g., audio recordings, videos, text to speech engines). |
| 3. | **Leverage Interactivity** | Offer interactive tools (e.g., quizzes, questionnaires, glossaries, tutorials) to engage with the information and provide performance feedback. Allow users to share information (e.g., print, email) with others. |
| 4. | **Provide Accurate, Colloquial, Comprehensive, Succinct Content** | Written information should be brief, relevant, and in users' vernacular. |
| 5. | **Provide Tailored, Flexible, Layered Content** | Prioritize information according to importance. If possible, personalise informtion. Provide succinct summaries but allow users to access more detailed information. Offer content in multiple languages. |
| 6. | **Use Visuals to Complement Text, But Avoid Tables** | Visuals (e.g., pictures, videos, animations) may enhance written information. If unavoidable, tables should should be designed as independent, simplistic representations of information |
| 7. | **Simplistic, Consistent Navigation** | Keep users oriented. Use linear navigation to facilitate forward and backward movement. Use large buttons, clearly labeled links, and provide a search engine. |
| 8. | **Simplistic, Consistent Displays** | Avoid on screen complexity. Avoid the need for scrolling by limiting information on a page / screen. |

*Table 2– Optional Evidence-Based Heuristics for Health Literacy and Usability For Specific Content or Device*

| | Heuristic | Description |
|---|---|---|
| 9. | **Clear and Comprehensive Communication of Risks** | Describe risk terminology in ways users will understand. Use 100 as upper limit on bar graphs. Avoid logarithmic scales. |
| 10. | **Clear Depiction of Monitoring Data and/or Test Results** | Emphasize values outside acceptable ranges. Facilitate pattern recognition and rapid identification of influential factors. |
| 11. | **Considerations for Mobile Devices** | Allow users to adjust the display size using familiar input (e.g., pinch to zoom, turning to landscape orientation). Use appropriately sized interface elements. Limit the amount of information displayed. |

The severity scale used for this evaluation was specifically developed for rating health literacy or usability issues identified in consumer HISs [6]. The three severity levels (i.e., mild moderate, severe) are used to [6]:

1. Prioritize issue resolution
2. Estimate the likelihood consumers will understand the content and the gravity of the consequences associated with misunderstanding
3. Indicate the extent to which users will be able to circumvent the obstacle posed by the issue

**System Under Evaluation**

A mobile blood pressure tracking application (app) was selected as the system for this evaluation. This app operates on iOS systems (i.e., iPhone, iPad, iPod) and the full version is available for $0.99 CAD. Although its primary purpose is to record blood pressure values over time, this app also tracks heart rate and weight. This app was selected because it is an affordable solution that may appeal to people with limited ehealth literacy who are at risk or have been diagnosed with high blood pressure.

**Procedure**

In addition to the eight essential heuristics, the optional heuristics, Clear Depiction of Monitoring Data and/or Test Results and Considerations for Mobile devices, were both relevant to this system and therefore applied in this evaluation.

Given that the mobile blood pressure tracking app aimed to facilitate the monitoring of data over a time period, the evaluation focused on two stages of app usage: 1) the initial profile generation, and 2) reviewing data trends. As such, the investigators populated the app with several blood pressure measurements, both in and out of the acceptable range. This approach is recommended for tracking/monitoring apps, as it makes the evaluation more representative of what users would view after using the system multiple times.

Two usability experts with no clinical expertise (HM and JG) used the heuristics while performing tasks to investigate a blood pressure app independently with the goal of identifying strengths and weaknesses of the application. For investigations aiming to identify potential issues with eHealth literacy, it is advisable that the evaluators do not have clinical expertise, as they may be better able to detect potential content issues (e.g., terminology, undefined acronyms) for representative users.

## Results

**Favourable Aspects of the Blood Pressure Tracking App**

The blood pressure tracking app provided opportunities to share the data users entered (e.g., email, print).

The app color coded text and data point values that were considered out of range leveraging the convention of green for normal values, yellow/orange to indicate prehypertension, red for hypertension, and blue to denote hypotension.

This app offered several different views of the entered data: a) a summary table depicting maximum, minimum, and average values; b) a graph of the data; c) a chart of the descriptive statistics; and d) a frequency table of how many values fell within each range. The date range (i.e., day, week, month, year) for each report is adjustable and also allows showing all values, or only those taken in am or pm. Individual entries can be modified in the history.

The majority of the information in this app was kept above the fold, eliminating the need for scrolling and minimizing the likelihood of missed information.

This app also offers the additional security feature of setting a passcode lock and allows users to backup and restore data through both WiFi and iCloud.

**Opportunities to Improve the Blood Pressure Tracking App**

For brevity, this section will only outline violations that were deemed moderate or severe, organized according to heuristic. The heuristic Clear and Comprehensive Communication of Risks was not evaluated and therefore not included here.

A total of 40 heuristic violations were identified in this analysis. This blood pressure tracking app had the most issues associated with its complex navigation (9) and display (8) (see Figure 1). Unfortunately, the majority of the violations identified were considered either moderate (18) or severe (17) in nature, either because they were insurmountable usability problems or they had the potential to misinform users. In the interest of brevity, only the violations deemed to be severe will be discussed. Both investigators identified 14 violations. The remaining unique issues were found by one investigator (HM = 23) or the other (JG = 3).

***Immediately Inform Users of Purpose and Engage Users, Avoid Registration***

The app forces the user to make a profile to enter data. It is not clear what values are mandatory. The app applies default values for birthday, weight, height, gender, goal blood pressure, goal heart rate, goal weight, which is not prudent. There is an explanation of the purpose of the field labeled "color range", which would likely confuse users. If multiple profiles exist in the app, the active profile is not obvious, which could result in adding data to the wrong profile.

***Use Complementary Interaction Methods***

This app fails to use any alternative methods to input or output information, which increases the probablilty of inaccurate data entry due to manual error. Additionally, the majority of values are entered using "pickers" (scrollable menus), which maybe be less efficient and more tedious than providing a numerical keyboard for data entry.

***Leverage Interactivity***

Although this app enables users to share their tracking data, it offers CSV, HTML, and PDF formats but does not describe why a user would select one file type over another. Additionally, this app does not engage users by offering any interactive learning tools or resources on blood pressure.

***Provide Accurate, Colloquial, Comprehensive, Succinct Content***

This app offers very limited content and therefore does not facilitate understanding the underlying mechanisms of blood pressure nor influencing factors. Unfortunately, the app uses multiple undefined acronyms (e.g., BP, HR, MAP, mmHg, bpm), which may be confusing for some users.

***Provide Tailored, Flexible, Layered Content***

Despite forcing users to create a profile, default goal values do not vary as a function of what is entered as current values nor clinical guidelines (e.g., using BMI for goal weight). As well, alerts are not provided when the user enters a value that would be considered outside of a healthy range. For example, entering a systolic value of >180 mmHg, which is considered to be a hypertensive crisis [8], does not produce an alert. Moreover, the app fails to incorporate additional information that is clinically relevant for blood pressure monitoring (e.g., whether a user is pregnant or has diabetes).

***Use Visuals to Complement Text, But Avoid Tables***

Very few visuals were used to complement text information. The few icons displayed were used suboptimally and felt busy, because they were often intermixed with data. Unexpectedly, the camera button captures a screenshot rather than a photo.

Unfortunately, multiple tables were used to display data, which would likely present challenges for users attempting to extract information from them.

***Simplistic, Consistent Navigation***

The app allows users to navigate through different date ranges; however, when a user navigates to date ranges too far in the past or future, there is no simple way to get back to the most current entries. The button to add a new entry is displayed in the top right corner on most pages, but is replaced with a camera button on some pages. The buttons to add weight, notes, or change the date of an entry are not obvious, which could cause users to become disoriented. Additionally, users are able to enter data for dates in the future, which is inadvisable. Further, it was not obvious that there were multiple different reports, as one of the investigators nearly missed the additional summaries entirely.

Adding a new notification, or reminder to take blood pressure was unnecessarily complex and had a different navigation pattern than other features. Though this is not a critical function of the app, it could be beneficial in facilitating consistent tracking by users.

***Simplistic, Consistent Displays***

The colors in the app are generally distracting (e.g., gradients, shadows) and low contrast. There are multiple lines (both solid and dashed) on the graphs which provide limited value and increase the impresson of a cluttered display.

When entering a value, no labels denote the systolic, diastolic, and heart rate on either the input component or display of entered information. Additionally, new entry dates are displayed only as numbers, a potentially confusing format.

There were three significant display inconsistencies of note. First, the scales on the graph change when different time spans are selected, presumably according to the range of values on the display. Second, the format of the PDF summary of values that can be shared by email were very different from any of the displays within the app. Finally, red, orange, green, and yellow are used inconsistently. For data points, they indicate thresholds within acceptable ranges, yet on other displays these colors are used strictly for differentiation and do not reflect whether the value entered is in or out of range. This inconsistency could potentially result in misinterpretation.

***Clear Depiction of Monitoring Data and/or Test Results***

The app uses orange for the systolic line on the graph and green for diastolic. This could create confusion if users interpret that the green diastolic line is always within range.

Although the information is presented in several ways, the tables and charts may be difficult for users to interpret and extract information from, and could potentially confuse them.

***Considerations for Mobile Devices***

Unfortunately, this app does not allow users to change the size of the font either by reorienting the mobile device or in the settings. Additionally, some of the buttons were small.

***Other***

Errors are likely to occur because the app automatically enters information. Specifically, the app saves its default values for blood pressure, heart rate, and/or weight values for any new entries, if they are saved without modification.

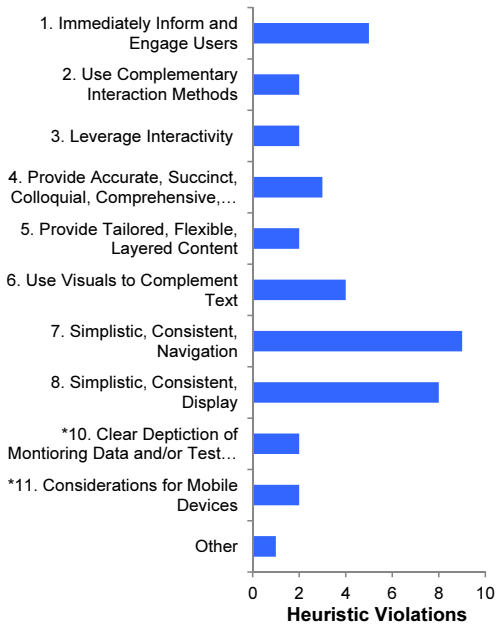


*Figure 1 – Frequency of Violations as a Function of Heuristic*
** Denotes optional heuristics relevant for this evaluation.*

## Proposed Revisions for the Blood Pressure Tracking App

Figure 2 was developed to depict design changes to improve the app, particularly for users with limited eHealth literacy, by resolving some of the issues identified in the heuristic evaluation. Generally, a more minimalistic, higher contrast appearance was adopted, to both emphasize the information and enhance readability.

Given that adding values is a primary task, this function was promoted to having its own button on the menu. Thus, users could easily add a new entry from anywhere within the app. Although this app did not connect with blood pressure cuffs, it is always preferable that where possible, data is automatically uploaded into consumer health applications but allows users to revise or complement data with additional information (e.g., a note). Additionally, as shown in Figure 2a, the proposed redesign provides a holistic view of all of the information that can be added to a new entry. In contrast, the existing app forces users to toggle between screens to add different types of information. This display also shows the labels and units of the information, unlike the existing app. Finally, icons are used to reinforce the data labels.

Several recommendations were used to simplify the graph display (see Figure 2b). Specifically, the acceptable range of values for systolic and diastolic blood pressure were superimposed onto the graph in light green to emphasize values in and out of range. This color coding scheme was continued further, by redundantly coloring acceptable values in green, while hypertensive values were orange or red depending on severity, and hypotensive values were colored blue. Additionally, it is advised that the color coding scheme adopted would be applied to summary tables and individual entries. To prevent disorientation, the revised display constrains users to viewing the graph with today as the most recent entry to prevent disorientation.

It is also recommended that the app would incorporate a glossary of terms and/or links to trusted references and educational resources in the tools (e.g., [8]) to facilitate users understand the concept of blood pressure, related terminology, and what factors affect blood pressure.


(a) (b)

*Figure 2 – Proposed Revised Displays for the Blood Pressure Tracking App*

## Discussion

Currently, the blood pressure tracking app has limited value to consumers due to the numerous moderate and severe potential usability and eHealth literacy demand problems identified here. It is not to say that users were not be able to use this system for monitoring, but it would not provide them with an enhanced understanding of what blood pressure is and what behaviours influence it. Users could also potentially misinterpret information or rely on default values. However, design modifications and the incorporation of actionable content could increase the usefulness and usability of this app.

This novel set of evidence-based heuristics derived from studies designing or evaluating consumer HISs for users with limited eHealth literacy, demonstrated utility in revealing potential problems Specifically, this evaluation revealed a number of opportunities to improve the blood pressure tracking app to improve its usability for consumers with limited eHealth literacy and how to more effectively communicate information to these users. The issues identified here stemmed from design issues with either the interface or the content that could be problematic for users with limited eHealth literacy. Moreover, given that users of these systems often have minimal or no clinical expertise, it is imperative that information is written and displayed in a manner that scaffolds understanding.

Leveraging findings from existing literature on usability and eHealth literacy to develop heuristics for inspecting other consumer HISs is a promising technique. Specifically, this method of developing evidence-based heuristics facilitates

mitigating known barriers to both use and comprehension for users with limited eHealth literacy with a single evaluation. Applying these heuristics could help ameliorate system content and design prior to full-scale usability testing.

This study expanded on previous work by incorporating additional evidence on usability and eHealth literacy. Our initial heuristics [6] were more specific, whereas the heuristics presented here were broader. There are advantages and disadvantages to using either set. Investigators with less familiarity with demands on eHealth literacy and usability issues may find it more helpful to use heuristics that provide specific guidance. Whereas, evaluators with more experience in these domains may find it preferable to use more general heuristics, as they are more flexible. This rationale may account for the differences in problem identification between inspectors in this study, as one inspector has more experience in this domain. Moreover, the heuristics presented are still preliminary, as they are still not entirely mutually exclusive and require more refinement. Further, as the body of research on eHealth literacy and usability continues to mount, emerging evidence should be continuously integrated into this set of heuristics.

The findings from this study suggest that additional heuristics are needed to classify all identified problems. That is, the "Other" category of problems had to be created to accommodate problems that were not subsumed in one of the existing heuristics. This suggests that the developed heuristics might benefit from being complemented with other heuristics such as Nielsen's [4] ten heuristics. Amalgamating the set of heuristics generated here with Nielsen's [4] could provide a more comprehensive set of principles for designing and evaluating consumer HISs is thus one proposed line of future research.

There are several other opportunities for further research using these heuristics. First, these heuristics may be useful for comparing and contrasting multiple consumer health information systems with similar purposes (e.g., health risk assessments, blood glucose monitoring apps) in an attempt to determine the most suitable of these systems for consumers with limited eHealth literacy. Another line of research that warrants investigation is testing the validity of these heuristics by comparing the problems found through their application with problems revealed through usability testing of the same system, to determine the correlation between the their respective findings.

## Conclusion

As the proliferation of consumer HISs continues, it is important to consider the usability and the demands these systems place on eHealth literacy. Some might argue that low cost applications should not be scrutinized, given their restricted resources. However, users with limited eHealth literacy are equally, if not more, likely to use these inexpensive systems. Thus, it is important to recognize and apply low-cost techniques, such as the one outlined in this paper, to improve consumer HISs of all varieties. Moreover, these heuristics facilitated the identification of both eHealth literacy and usability problems with only a single evaluation.

Consumer HISs have the potential to engage and empower new user groups to monitor and improve their health. That is, these systems could possibly increase users' participation in their own healthcare by providing personalized feedback and tailored interventions that cater to the needs and preferences of their users. However, for this information to be received and applied by the users who have challenges using technology and difficulty understanding health information, it is imperative that they are designed with usefulness, usability, and eHealth literacy considerations.

Although heuristic evaluation with evidence-based heuristics may be valuable for informing the design of consumer HISs to mitigate potential problems for users with limited eHealth literacy, it is not meant to replace usability testing with representative users. Instead, such heuristic evaluation should be used as a preliminary filter to identify and resolve issues commonly experienced by limited literacy users. Thus, it would facilitate development of more usable applications, as less time would be spent repeatedly identifying problems through usability testing that are known problems, previously cited in the literature. That is, using evidence-based heuristics (i.e., design principles for users with limited eHealth literacy) as a preliminary method of improving a consumer HIS, should result in more effective use of representative users finding problems unique to a specific consumer HISs under investigation. Thus, this method should be used in conjunction with other user-centred design methods as a part of an exhaustive, iterative design process to ensure that consumer HISs are easy to use and users understand the information contained therein.

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**Address for correspondence**

Helen Monkman, School of Health Information Science, University of Victoria, Victoria, BC, Canada, email: monkman@uvic.ca