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Mobile Health Technology Accessible to People with Visual Impairments

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Abstract

Although there is a potential of mobile health (mHealth) technology to facilitate self-care of people with visual impairments, less attention has been paid to accessibility of mHealth technology. The study aims at investigating the degree to which the mainstream mobile health applications (apps) that are commercially available on the market are compliant with accessibility standards. The Web Content Accessibility Guidelines (WCAG) 2.0 was used for checking the apps' accessibility. The accessibility problems found were associated with the WCAG accessibility principles – i.e., perceivable, operable, understandable, and robust. It is recommended that user interfaces be presentable to users in ways that they can perceive; users receive a set of user interfaces that would not require any interaction that they cannot perform; users be able to understand the information and the operation of the user interfaces; and health apps provide a variety of features and functions that are compatible with the device and operating system version. As health care consumers with visual impairments are increasingly using health apps for self-care today, we should ensure that those health apps are adequately designed to accommodate those with visual impairments.

Keywords

Mobile Health (mHealth), Accessibility, Visual Impairments, Human Factors, Human-Computer Interaction

Introduction

People with disabilities are likely to encounter disparities in accessing preventive health care and wellness services (Jones et al. 515) due to poor accessibility in health care facilities, equipment, health promotion, health insurance, and disease prevention programs and services for people with visual impairments (Kim 1; National Council on Disability; O'Day et al. 193), likely leading to poorer health conditions as compared to their sighted peers (Capella-McDonnall 133; Centers for Disease Control and Prevention). Yet, there is a potential of technology interventions (e.g., mobile health [mHealth] applications [apps]) to facilitate self-care of those with visual impairments (Anderson et al. e0156164). Today, healthcare consumers tend to show high rates of adoption of mobile health applications.

However, less attention has been paid to accessibility of mHealth apps to those with disabilities (Jones et al. 515). In 2016 a survey report (Pew Research Center) uncovered that 68% of general populations in the United States own a smartphone and a national survey (Morris et al.) in 2016 found that 71% of people with disabilities own a smartphone. Despite the similar smartphone technology adoption rate between those with and without disabilities, the adoption rate (17%) of mHealth apps by people with disabilities was considerably lower than that (34%) by their peers without disabilities (Jones et al. 515). A systematic literature review in 2018 (Jones et al. 515) indicates that the mHealth research and development (R&D) for people with disabilities is still in its early stages; health apps targeting people with disabilities merely account for a small fraction of health apps on the market; and poor accessible designs of mHealth apps are barriers to mHealth adoption in people with disabilities.

As healthcare consumers with visual impairments are increasingly using health apps for self-care, it should be ensured to investigate the degree to which those health apps are adequately designed to accommodate those with visual impairments. Otherwise, such insufficiently tested apps would lead to a potential for those with visual impairments to ill-advisedly change their self-care regimens and ultimately develop adverse health outcomes. As the primary focus of mHealth has typically been placed on people without disabilities, the proliferation of mHealth could ironically worsen health disparities in the United States when inaccessible designs remain on the mHealth apps for those with disabilities. “Self-care” apps typically transfer many of the responsibility to the end users, such that good accessibility of the health apps is imperative for those with visual impairments.

As there is lack of research on accessibility associated with self-care apps for visually impaired people, the study aims at investigating the degree to which the mainstream self-care apps that are commercially available on the market are compliant with accessibility standards.

Methods

A health mobile app’s accessibility was checked against the Web Content Accessibility Guidelines (WCAG) 2.0 of the World Wide Web Consortium (W3C) that consist of four main themes: perceivable, operable, understandable, and robust. The fully detailed descriptions of the four themes are available at www.w3.org (Patch et al.). As this study focused on people with visual impairments, the use of a screen reader *VoiceOver* contributed to adequately finding accessibility problems, while checking an app’s accessibility along with the WCAG’s guidelines.

According to a national survey (Krebs and Duncan e101), the most used self-care apps among mobile phone owners in the United States include Walgreens (Ver. 7.3), Fitbit (Ver. 2.51), Web MD (Ver. 5.0), Nike+ (Ver. 5.15), and iTrackBites (Ver. 5.7.5). This study thus used those five apps for accessibility checking; yet, the app Weight Watchers was replaced with the app iTrackBites as it is not free of charge any longer. The iTrackBites includes nearly every feature of the Weight Watchers and is also used considerably by many healthcare consumers today (Business Insider). Those apps were downloaded from the Apple app store and installed in an iPhone 8 (i.e., 4.7-inch LCD multi-touch display with 1334-by-750 pixel resolution at 1400:1 contrast ratio).

Results

As the primary goal of this study was to explore accessibility problems across health apps, we did not focus on criticizing a specific app. This study has no relationship with any of the selected apps' manufacturers. The accessibility problems relevant to the WCAG's themes (i.e., perceivable, operable, understandable, and robust) were thus reported without linking to a specific health app's name.

WCAG Principle 1: "Perceivable"

The WCAG principle 1 (perceivable) recommends that user interface components be presentable to users in ways that they can perceive. Yet, the health apps included user interface components that were not perceivable due to information overload, poor contrast, and inadequate zoom/magnification.

Information Overload

While the WCAG mobile accessibility guidelines recommend that an app minimize the amount of information on each page by considering the small-sized screen, the health apps in this study were not compliant with the recommendation as they included heavy texts. The WCAG guideline also recommends that a hypertext be short; however, certain drug names were typically long, ultimately resulting in very lengthy hypertexts. Furthermore, those names were partially displayed only with the first few words followed by three dots. As the users had a limited access to information about drug names, they are likely to end up with lack of understanding or misunderstanding.

Poor Contrast

Smartphones are often used outdoors where strong sunlight could interfere with reading texts on screen. Thus, good contrast is essential for users with low vision to secure good readability. However, the health apps had texts embedded onto vivid color background images so that it would be difficult to read.

Inadequate Zoom

The smartphone technology supports the feature “Dynamic Type” that allows users choose their preferred size via a pinch-zoom gesture. The health app could also enlarge texts (e.g., weight charts with tiny numbers and labels); yet, those enlarged texts became unreadable because they appeared to be scrambled and overlapping in the limited screen space.

WCAG Principle 2: “Operable”

The WCAG guideline principle 2 (operable) recommends that users receive a set of interfaces that would not require any interaction that a user cannot perform. However, the health apps did not meet the WCAG guidelines associated with user interfaces of graphics, animations, popup windows, and multi-finger gesture commands.

No Access to Graphical User Interfaces

The health apps had a group of action buttons and hypertexts that were placed too far or too close to each other, likely leading to a human error. When a screen reader feature was off, a button was clickable; however, when a screen reader feature was on, the button became unclickable. The health apps did not allow a screen reader to recognize a search box even though a finger touched the search box. The auto-complete feature in the search box (e.g., search keyword suggestions) was not accessible via a screen reader. When the search results also returned “*no findings*”, the message “*no findings*” was presented visually only, but not orally via a screen reader.

No Access to Animated Interfaces

The health apps took advantage of animations to facilitate user understanding of complicated medical information. For example, if a finger touches a certain part of an animated human body (e.g., head, chest, and back), the user is supposed to obtain information about pre-populated symptoms and potential medical conditions. Unfortunately, the health app did not allow a screen reader to recognize the animation at all.

No Access to Popup Window Interfaces

The health apps were not programmed to help visually impaired users get informed of unexpected occurrences, such as error messages in popup windows. For example, when a wrong ID or password was entered, a red warning message was displayed without any audio warning messages. When a popup menu showed up to help users select options, no audio message was provided so that those with visual impairments were likely unaware of the popup menu.

No Access to Multi-finger Gesture Interfaces

When the cursor was located on a menu button and a user tried to use a certain finger-gesture command (e.g., three-finger swipe down), the health app did not recognize the command. The health apps accepted the command only after the user touched anywhere except the menu button.

WCAG Principle 3: “Understandable”

The WCAG 2.0 guideline principle 3 (understandable) recommends that users be able to understand the information as well as the operation of the user interfaces. Yet, the health apps included a less user-centered page layout and a combination of incomplete-, incorrect-, and no-description about user interface components.

Less User-Centered Designs of Page Layouts

The health apps included multiple pages that were not presented in a consistent layout. While some pages had a horizontal menu bar on the top of the page, other pages had a vertical menu bar or a combination of vertical and horizontal menu bars. Users with visual impairments may encounter difficulties in developing a mental model if they use the app for the first time. Although the WCAG guidelines recommend that a mobile application enable users to switch orientations between landscape and portrait, the health apps did not allow users to switch. Given the limited screen size of a mobile phone, it is recommended to position information on the first page without scrolling down. However, the health apps required users to keep scrolling down to have access to the majority of information. Such inaccessibility issue occurred due to many big images and buttons. Those graphic designs may appear to be fancy to sighted users but cause visually impaired users to miss important information.

In-Complete Description

The health apps provided incomplete descriptions of user interfaces via a screen reader. Many icons appear to be a fancy image instead of a button that obviously appears to be clickable. In order to help users with visual impairments understand that such a fancy image is an actionable icon, the image should include ALT tags (also known as *alternative text*) in computer programming codes. Thus, a screen reader will properly read out the alternative text for the image. However, this study found that when a finger touched an action icon, the screen reader merely said, for example, "*A button*" and "*Tapped one of five.*" The action icons failed to let users have access to detailed information about whether the icon is actionable or what would occur if the user clicks the icon.

In-Correct Description

Although the health apps provided some descriptions of user interfaces (e.g., drop-down menus, like buttons, and navigations) via a screen reader, those descriptions were not always correct. An accessibility problem occurred when a screen reader tried to read out a drop-down menu list. Although the list included a label, the label failed to inform users that the list is actionable. Thus, a screen reader merely did read out the label per se and a user was likely to think of it as text, instead of a drop-down menu list. In general, a “like” button includes a numeric value to indicate how many people are in favor of certain content. If the like button includes, for example, the numeric value “320”, a screen reader would merely read out “320 button”, which is likely to lead to a misunderstanding that there is a button named “320” or that there are 320 buttons.

No Description

The health apps did often not provide any description of user interface components. For example, a screen reader did not notify a user that there were additional contents available, located below the bottom of the page. Sighted users could see a small portion of an image (or texts) at the bottom edge of the page so that they could easily notice that they could read more information if they kept scrolling down the page, but visually impaired users would have no access to such a visual cue. In addition, the health apps provided a lot of data via images such as graphs, charts, and diagrams to display personal health data. Yet, the apps were not programmed to let a screen reader read out those image-based information. The health apps also disallowed a screen reader to read out texts that were embedded in background images. When a finger touched the weight-tracking menu to read weight changes, a screen reader merely read out the numeric values without informing users about the meaning of each value. The health apps should have been programmed to speak, for example, “134.0 lbs. for Weight”, “0.0 lbs. for Change”, and “0.0 lbs. for Total Loss.” As smartphone technology advances, touchscreen-based gesture interactions are likely becoming diverse and complex. The WCAG suggests that apps provide instructions (e.g., overlays, tooltips, and tutorials) to explain what gestures can be used to control interfaces and whether there are alternatives. Yet, the health apps failed to provide adequate instructions.

WCAG Principle 4: “Robust”

The WCAG 2.0 also emphasizes the degree to which an app provides a variety of features and functions that are compatible with the device and operating system version. Most platforms (e.g., Android and iOS) have the ability to set large fonts, but the health apps did not honor it.

Discussion

This study used the WCAG 2.0 mobile accessibility checklists to investigate the user interfaces of health apps, and found multiple accessibility problems that were associated with the WCAG accessibility principles of perceivable, operable, understandable, and robust user interfaces.

Perceivable

Despite the limited screen size, the health apps contained too much information on each page, which is less likely for visually impaired users to perceive successfully the information being presented. As opposed to sighted users who can quickly scan the whole page structures, headings, and paragraphs, a screen reader gives visually impaired users a limited access to such a quick overview (Ahmed et al. 367). To avoid the visually impaired users’ frustration, ineffectiveness, and inefficiency in performance, a page should not be overloaded with information. Another design problem was caused by a large image on the limited screen size that covered the entire page. The large sized images were often found in the exercise-tracking app, and designed to appear sporty by including images of people doing exercises (e.g., running). It is well documented (Tiggemann and Zaccardo 61) that an image of people doing exercise is likely to encourage and inspire viewers to attain their health and fitness goals, which is referred to as "fitspiration" – i.e., the amalgamation of the words *fitness* and *inspiration*. However, such a fitspiration strategy using an image in the health apps would not be accessible to visually impaired users who rely on a screen reader. Those health apps should have used an alternative means to encourage visually impaired users – i.e., accessible fitspiration.

Operable

The inoperability problems were caused by multiple design issues (e.g., unrecognizable interfaces by a screen reader and unresponsive touch-commands). It would be critical to fix the accessibility problems in the first place but also properly inform a user about error status. A system with an unrecognizable user interface is akin to driving in an unfamiliar city without a roadmap and street signs (Bilyayeva), likely resulting in a car accident. Health app designs should rigorously meet the accessibility standards; otherwise, it would lead to a health/safety incident caused by human errors.

Understandable

User interface components of the health apps included the operation and the information that would be less likely to be understood by users with visual impairments due to no, incomplete, and incorrect descriptions of user interfaces via a screen reader. A user is less likely to understand or even guess what would happen if they click the button. As it is a health app, a user may want to be careful instead of clicking here and there for the trial-and-error learning approach. When a button is touched, a screen reader simply speaks “Tapped one of five” leading to a more confusion about whether a user tapped a button, a text, a text field, or something else. It is well documented (Norman 38) that the design principle “*Affordance*” should be well integrated in a system design for users. Affordance refers to an enhanced user understanding in which users can fully understand about how to use a system even before users start using it (e.g., a button figure for push action, an on/off switch figure for flip action, and a knob figure for rotate action). The “affordance” designs should also be accessible to those with visual impairments.

Robust

The operating systems of mobile technology have been advanced by allowing users to obtain alternative ways to interact with mobile apps via assistive technology features (e.g., screen reader and magnification). However, it does not mean that all the mobile apps today are designed to be fully compatible with assistive technology features. For example, the health apps did not follow the operating system’s control of enlarging the text size. It should be recommended that a health app be compatible with the smartphone device operating system.

Conclusion

Although there is a potential of mHealth technology to facilitate self-care of those with visual impairments, less attention has been paid to the accessibility of mHealth apps. This study focused on advancing understanding of the degree to which the health apps today are accessible to those with visual impairments. Multiple accessibility problems were found against the WCAG 2.0 mobile accessibility checklists. Those problems were associated with the WCAG accessibility principles of perceivable, operable, understandable, and robust. As health care consumers with visual impairments are increasingly using health apps for self-care, we should ensure that those health apps are adequately designed to accommodate those with visual impairments.

Acknowledgments

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