Usability Testing of a Progressive Web App for Women with Cardiac Pain

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Abstract

Background: Cardiac pain has been widely considered to be the primary indicator of coronary artery disease. The presentation of cardiac pain and associated symptoms vary in women, making it challenging to interpret as cardiac, possibly cardiac, or non-cardiac. Women prefer to consult with family and friends instead of seeking immediate medical care.

Objective: To assess user performance (i.e., ease of use, efficiency, and errors) and user satisfaction (SUS) with the content and functionality of a progressive Web App for women with cardiac pain.

Methods: Following ethics approval, a purposive sample of women over 18 years with cardiac pain or associated symptoms lasting greater than 3 months, and able to speak and read English were recruited to participate in two iterative usability testing cycles. The first cycle assessed the performance and satisfaction of at heart using a web-based computer interface and the second cycle assessed the performance and satisfaction of at heart across various Android and Apple iOS devices. Two investigators recorded user comments and documented problems. Three error types were captured: 1) navigation errors, 2) presentation errors, and 3) control usage errors. At the end of the testing session, the participants completed the System Usability Scale (SUS) and four semi-structured interview questions.

Results: Ten eligible women participated in usability testing from March 31st to April 17th, 2020 (Cycle 1) and November 17th to November 30th, 2020 (Cycle 2). Women across usability cycles had a mean age of 55.6 years (SD 7.3) and most were well educated (n=9, 90%). Fifty percent of women were employed full or part time and earned greater than $70,000 Canadian dollars annually (n=6, 60%). Participants across two cycles of testing reported the overall usability of the at heart web-based application as highly acceptable (SUS mean 81.75, standard deviation [SD] 10.41). Nine (90%) participants rated the user-friendliness of at heart as good or excellent. All participants (n=10, 100%) thought at heart was easy to use and efficient. Only two testing errors were noted as high priority, these were low contrast/small font and clarification that the Chatbot was not a real person. User satisfaction was assessed using themes that emerged from the debrief and four semi-structured interview questions; at heart was engaging, comprehensive, understandable, credible, relevant, affirming, personalized, and innovative.

Conclusions: at heart is the first of its kind; no smartphone or web-based self-management program has been co-designed and

systematically developed with women who have lived experience, and then tested with women who have cardiac pain. This study provides strong initial support for the at heart web-based application for women living with cardiac pain and cardiac symptoms. Findings from the second usability testing cycle will be used to refine the prototype prior to the pilot randomized controlled trial.

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User satisfaction was assessed using themes that emerged from the debrief and four semi-structured interview questions; *at heart* was engaging, comprehensive, understandable, credible, relevant, affirming, personalized, and innovative.

Conclusions: *at heart* is the first of its kind; no smartphone or web-based self-management program has been co-designed and systematically developed with women who have lived experience, and then tested with women who have cardiac pain. This study provides strong initial support for the *at heart* web-based application for women living with cardiac pain and cardiac symptoms. Findings from the second usability testing cycle will be used to refine the prototype prior to the pilot randomized controlled trial.

Keywords digital health; Chatbot; women; cardiac pain; usability testing; self-management

Introduction

Cardiovascular diseases (CVD) constitute the leading cause of mortality globally, exerting a substantial economic burden on the healthcare system.[1-4] As the most prevalent form of CVD, coronary artery disease (CAD) is estimated to be associated with 8.93 million deaths annually worldwide across all ages.[1] CAD is a complex condition that varies in clinical presentation across sex, with both obstructive (macrovascular) and non-obstructive (microvascular) CAD being associated with cardiac pain and other associated symptoms.[5] Although cardiac pain has been widely considered to be the primary indicator of CAD,[6] cardiac pain and associated symptoms reported by women with CAD differ markedly from that of men.[7,8] The presentation of cardiac pain and associated symptoms may vary in frequency, pattern, and distribution in women,[8] making it challenging to interpret as cardiac-specific.[9] Similarly, women that undergo percutaneous coronary intervention (PCI) and/or cardiac surgery report higher prevalence of persistent pain of moderate to severe intensity post-treatment, as compared to men.[10-12] This cardiac pain is often described by women as sharp and burning, and may present with varying extent of dyspnea, fatigue, anxiety, and discomfort that may radiate to the jaws, shoulders, back, and arms.[6,8,13] The manifestations of cardiac pain and associated symptoms contribute to substantial morbidity and impairments in health-related quality of life (HRQoL) in women.[14,15]

The complex presentation of CAD in women presents a challenge for timely detection and management of symptoms. Recent data have shown that women often delay seeking medical care when experiencing acute cardiac pain and/or associated symptoms, with time between symptom onset to emergency department arrival being 85-320 minutes.[16] Women report experiencing difficulties in interpreting, understanding, and attributing their cardiac pain and/or symptoms to CAD, preferring to consult with family and friends instead of seeking immediate medical care.[17] Moreover, women often hesitate to seek medical care for cardiac pain and/or associated symptoms as a result of their gendered roles as caregivers.[17,18] Women describe having gendered roles that they are

unable to delegate, such as providing care for dependent family members.[17,18] The cumulative effect of symptom under-recognition and hesitancy in women leads to delayed care-seeking behaviours and an increased risk of major adverse cardiac events (MACE) and/or mortality, as compared to men.[6] As such, it is imperative to promote proper recognition, assessment, and management of symptoms in women to improve health outcomes and HRQoL.

Self-management programs are designed to engage users as active participants in the management of their condition; they are key predictors in successful behaviour change.[19,20] These interventions generally utilize educational strategies designed to assist users in achieving optimal knowledge, understanding beliefs, skills, as well as providing meaningful social supports.[21] However, inadequate access to self-management programs due to a lack of available services and barriers to access (e.g. geographical constraints) may limit user uptake.[22] In recent years, the use of digital health interventions has been on the rise.[23-25] Services and programs delivered through a digital platform can effectively reduce barriers to user access and care.[26] Many women describe digital health interventions as being novel and supportive,[27] effective in motivating healthy behaviours, reducing symptoms,[28] and improving HRQoL.[29] Digital health-based self-management programs have been developed and effectively used to help women manage weight,[27,29-31] increase physical activity,[32] monitor for perinatal depression, and assist with post-partum smoking cessation.[33] In spite of this, there is a lack of evidence-informed digital health self-management programs specifically for women with CAD living with cardiac pain and associated symptoms,[7] demonstrating a clear need for digital self-management programs for this population. In response, *at heart* (formerly HEARTPA♀N), a digital health self-management program for women with CAD living with cardiac pain and/or associated symptoms was developed.[34] *at heart* is a progressive web-based application consisting of a Chatbot, evidence-informed symptom triage algorithms, and a user-tailored library with educational strategies to support women's self-management of their physical, mental, emotional, and spiritual health and well-being.[34] This program was developed using a sequential

phased approach recommended by the Medical Research Council (MRC).[35-37]

In Phase 1, an integrated mixed method systematic review was conducted to evaluate the current evidence related to the self-management of cardiac pain and associated symptoms in women.[7,34] The results of the review suggested self-management interventions could reduce cardiac pain and associated symptoms if they targeted a greater proportion of women (standardized mean difference [SMD], -0.01; standard error, 0.003; P=.02), goal setting (SMD, -0.26; 95% confidence interval [CI], -0.49 to -0.03), and collaboration or support from a health care provider (SMD, -0.57; 95% CI, -1.00 to -0.14).[38] The review also identified a lack of self-management interventions targeted specifically for cardiac pain and associated symptoms in women.[38] In Phase 2a, the content/core feature set, Chatbot, and symptom triage algorithms were developed with input from healthcare professionals and women with lived experiences of obstructive/non-obstructive CAD and PCI/cardiac surgery.[34] In Phase 2b, the usability of *at heart* was evaluated to ensure that the platform was intuitive and acceptable to women with cardiac pain, and is the focus of this paper. In Phase 3, a process and preliminary efficacy evaluation using a two-group parallel pilot RCT will be undertaken.

Usability testing is an important phase in the development of a digital health intervention.[39,40] End users test a prototype using iterative cycles; they provide feedback about what works, what does not work, and where gaps might exist in the information and functionality.[39,40] These factors contribute to the frequency of use, understanding, acceptability, and enhance the likelihood that users will use the end product.[40,41] Testing the usability of the intervention also serves to assess the suitability of the platform interface and content.[42] The usability of the *at heart* progressive web-based application focuses on a think-aloud scenario-based approach to assess user performance (i.e., ease of use, efficiency, and errors) and satisfaction (SUS) with the prototype content and functionality. Three to five participants are usually adequate to identify 85% of major usability issues.[43]

Methods

Participant Selection

Following ethics approval a purposive sample of women was recruited from: 1) an ambulatory care hospital focused on women's health, 2) an adult tertiary care transitional pain clinic, 4) the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) registry, 5) the CorHealth Ontario Cardiac Registry, 6) established strategies through the Canadian Pain Coalition (CPC), 6) the Ontario Women's Health Network's (OWHN) listserv that reaches more than 1,900 women and community organizations in Ontario, and 7) social media. The OWHN regularly brought women who lived in rural and remote areas together; including women who were disabled, women of color, women with low incomes, and Indigenous and elderly women. Women were eligible to participate in the usability testing if they were: 1) greater than 18 years of age, 2) had been diagnosed with obstructive/non-obstructive CAD pain or pain post-PCI/cardiac surgery lasting greater than 3 months, and 3) able to speak and read English. Women were excluded from the study if they had: 1) severe cognitive impairment, assessed using the Six-Item Screener administered by telephone, 2) a major comorbid medical or psychiatric condition that would preclude their ability to participate in the usability testing. The Phase 2b usability testing was approved by the Health Sciences Research Ethics Board (REB) (36415) at the University of Toronto on November 26, 2018, and the Health Sciences & Affiliated Teaching Hospitals REB (6026830) at Queen's University on June 20, 2019.

Study Design and Procedures

Thinking aloud, field observation, and questionnaires were used to refine and evaluate the usability of the *at heart* progressive web-based application across various platforms. The two-phase iterative rapid design development focused on user performance (i.e., ease of use, efficiency, and errors) of the interface and user satisfaction with program content and functionality. A sample of 10 eligible women was recruited to participate in the iterative usability testing cycles (five women participated in each of two testing cycles). The first cycle assessed the performance and satisfaction of *at heart* using a web-based computer interface and the second cycle assessed the performance and

satisfaction of *at heart* across various Android and Apple iOS devices (i.e., Smartphones and tablets).

Informed consent and a *Demographic and Clinical Information Form* were obtained from

participants prior to each iterative cycle. Participants were provided with a brief explanation of the

study and the *at heart* progressive web-based application prior to undergoing a 60–90-minute one-

on-one observation period conducted through the Zoom video conferencing platform. Participants

were introduced to a case of a 54-year-old woman with symptoms that were 'possibly cardiac'[44] and

asked to progress through a set of standardized scenarios that incorporated each core feature set of *at*

heart. The 'think aloud' approach was used to capture the user's thought process and problem

solving as they progressed through *at heart* in a systematic manner.

Table 1. Usability testing workflow

Introduction to Tracey
Tracey is a 54-year-old woman who is married with 2 grown children. Retired from hairdressing for 3 years and husband is a cook in a local diner. She has a history of smoking and both mother and father had cardiovascular disease. On an average day Tracey gets fatigued easily, which affects her mood and interactions with her family.
Symptoms of her most recent cardiac event: sweating, nausea, dull pain left side of chest, numbness in right arm, vomiting.
Medications include Eltroxin, Novolin NPH, Nitroglycerin spray, Ferrous Gluconate
Introduction to Remote Testing
Introduction to WebApp prototype, early stages of development, data will not be stored. Importance of feedback during each of the five scenarios.

Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Sign-In and Event Profile **Workflow**	Heart Check **Workflow (Chatbot-Guided)**	Wellness Check (Chatbot with Content Delivery) More	Library **Workflow**	Library Retrieval and Notes
1. Sign-up form	1. Symptoms are different or worse than daily	information provided about	1. Access library	**Workflow**
2. First interaction with Chatbot	2. Symptoms are the same as	Tracey: poor mood.	2. View 'Coronary Heart Disease' article and favourite it	1. Go to Library
3. Event Profile creation	Event Profile	**Workflow (Chatbot-Guided)**	3. Go back to library and then to favourites	2. Find Bedtime Routine
Scenario Debrief	3. Nitroglycerin did not help	1. Interact with Wellness Check	4. Search library	3. Find and write a note
Likes, dislikes, expectations	4. Go to Emergency Department (ED)	sliders	**Scenario Debrief**	**Scenario Debrief**
	Scenario Debrief	2. View sleep self-management	Library content Favourites functionality	Likes, dislikes, note functionality
	Likes, dislikes, if it was suggested	article from		

you go to the ED would you go? Could you summon a Heart Check? How often would you want to do a Heart Check?	library 'Improving Your Sleep' 3. Find 'Relaxation Training' article 4. Navigate back to Chatbot 5. View 'Cognitive Behavioural Therapy' article **Scenario Debrief** Likes, dislikes, content delivery

Overall Questions: 1) Would you use this WebApp? 2) Where would it fit into your schedule? How often would you use it?

Two investigators recorded user comments and documented any problems encountered during each scenario using the *Usability Testing Error and Efficiency Documentation Form*. Three error types were captured on this form: 1) navigation errors (i.e., failure to locate function, follow recommended screen flow), 2) presentation errors (i.e., selection errors due to labeling ambiguities), and 3) control usage errors (i.e., improper entry field errors). After each scenario, the participants completed a series of debrief questions pertaining to their experience with each core feature. At the end of the testing session, the participants were asked to complete the *System Usability Scale* (SUS) to report their general experience with the web-based application. The SUS consists of ten 5-point Likert scale items that can be scored to provide a point estimate of usability with a reliability of 0.85, and has been validated across a range of interfaces, including web pages and web-based applications.[45,46] Scores range from 0 – 100, with scores greater than 70 having higher usability/acceptability. An adjective scale statement was added to the bottom of the SUS so that participants could rate the overall user friendliness of at heart as 'worst imaginable', 'awful', 'poor', 'ok', 'good', 'excellent', or 'best imaginable'. Numerical equivalents of 1 (worst imaginable) to 7 (best imaginable) were assigned to the adjectives for scoring. In addition, the participants were asked a set of four semi-structured interview questions to evaluate the user's overall impression of *at heart*, what they liked

and why, what could be improved, and if anything was missing. After the first phase, revisions were made to the interface and the revised user interface was tested in a subsequent iterative cycle.

at heart Self-Management Web-Based Application

at heart is a novel progressive web-based application that consists of three core features: Heart Check, Wellness Check, and a Library. Users are guided through the core feature set by a virtual interactive Chatbot that manages content and conversations. An Event Profile is created on the initial log-in to the self-management web-based application. The Event Profile contains individualized or personalized data that includes the quality and location of cardiac pain and/or associated symptoms experienced at the time of participant's last heart event (i.e., treated in the emergency department). Female front and back full body maps were specifically developed for *at heart,* using the chest pain and/or associated symptom locations most commonly described in the literature.[6,8,13]

-Insert Figure 1-

Chatbot 'Holly' asks women a similar series of cardiac pain and symptom assessment questions in the Heart Check, which is programmed into the *at heart* web-based application to occur at every three days. The Heart Check can occur more frequently simply by asking Chatbot 'Holly' for a Heart Check. Rule-based symptom triage algorithms compare each Heart Check to the individually stored Event Profile to make recommendations on an appropriate level of care. Level of care recommendations are based on the similarity and timing of current cardiac pain/discomfort to that stored Event Profile; noting similarities between the current and previous descriptions of the quality (i.e., heavy, tight, pressure, etc.), location, radiation, and associated symptoms. Recommendations are assigned into one of three categories: 1) 'red' or high risk (i.e., similar, or high-risk symptoms that have occurred within 24 hours), 2) 'yellow' or moderate risk (i.e., similar, or high-risk symptoms that have occurred beyond 24 hours but within seven days), and 3) 'green' or low risk (i.e., no similar or high-risk symptoms). Women who categorize as 'red' are encouraged to

notify a family member of their current symptoms and call '911' (i.e., to seek appropriate and urgent assessment of their symptoms). Women who categorize as 'yellow' are encouraged to see their primary care provider within 48 hours, and women who categorize as 'green' are permitted access to the self-management web-based application. High risk symptoms are defined as three or more new typical symptom features (i.e., dull, heavy or tight chest pain)[47] or any new associated symptoms includes shortness of breath, palpitations, a racing heart rate, or feeling lightheaded, faint or dizzy.[47,48] Women complete the Wellness Check, developed using the Brief Pain Inventory Interference Subscale,[49] to indicate the degree that cardiac pain and/or associated symptoms interfere with seven domains of life, which includes general activities, paid and unpaid work, walking, mood, relations with others, sleep, and overall enjoyment of life. Wellness Checks are programmed to occur at a minimum of every seven days and if the score in any domain is below a threshold, the Chatbot uses rule-based algorithms to deliver educational content from the Library (i.e., evidence about women with heart disease, wellness articles) to the end user.

-Insert Figure 2-

The Library also contains videos and podcasts from women with lived experiences of CAD. *at heart* was evaluated by Health Canada and deemed not to be a medical device as defined in the Guidance Document: Software as a Medical Device (SaMD): Classification Examples.[50] *at heart* provides self-management support to women who have heart disease and through a Chatbot, guides women to the most appropriate form of assessment (i.e., primary care, emergent care) based on their medical symptoms.

Data Analysis

Quantitative descriptive data from the *Demographic and Clinical Information Form* and the *SUS* were analyzed using IBM SPSS Statistics (Version 29). Field notes (i.e., user actions and verbalizations) and data from the *Usability Testing Error and Efficiency Documentation Form* were reviewed after each iterative cycle. Conventional content analysis was used to analyze the data, as

outlined by Sandelowski.[51] Two independent researchers assigned codes to label key actions, thoughts, and ideas. Related codes were grouped into categories and any disagreements were discussed between the two researchers. A list of interface issues was generated and prioritized based on risk to patients and ease of improvement.[52] Modifications were communicated to the website design and development team. Prototype changes made after each iterative cycle were evaluated in subsequent iterative cycles. Iterative cycles continued until no new data emerged.

Results
Participant Characteristics

Ten women meeting the eligibility criteria were invited to participate in the usability testing from March 31st to April 17th, 2020 (Cycle 1) and November 17th to November 30th, 2020 (Cycle 2). Women across usability cycles had a mean age of 55.6 years (SD 7.3) and most had a diploma (n=5, 50%), undergraduate (n=2, 20%) or graduate (n=2, 20%) degree. Fifty percent of women were employed full (n=3, 30%) or part time (n=2, 20%) and earned greater than $70,000 Canadian dollars annually (n=6, 60%); five (50%) lived with a disability, five (50%) were the primary household earner, and eight (80%) were the primary person responsible for housework in the home. Most women reported cardiac pain and/or associated symptoms for one to two years (n=3, 30%), two to five years (n=3, 30%) or greater than five years (n=3, 30%). The most common co-morbid conditions included depression (n=4, 40%) and anxiety (n=4, 40%), and four women (40%) had a previous myocardial infarction. Participant demographics by usability cycle are reported in Table 2.

Table 2. Participant characteristics

Characteristics	Cycle 1 (n=5)	Cycle 2 (n=5)
Age (years), mean (SD)	58.4 (4.827)	52.8 (8.872)
Gender Identity (woman), n (%)	5 (100)	5 (100)
Indigenous, n (%)	0 (0)	0 (0)
Identifies as Visible Minority, n (%)	1 (20)	1 (20)
Lives with a Disability, n (%)	2 (40)	3 (60)
Gender Roles (housework hours), mean (SD)	6.6 (5.1)	10.2 (8.0)
Primary Housework, n (%)	4 (80)	4 (80)
Education, n (%)		
High School	0 (0)	1 (20)

Diploma	2 (40)	3 (60)
Bachelor's Degree	2 (40)	0 (0)
Master's Degree	1 (20)	1 (20)
Employment Status, n (%)		
Full time	1 (20)	2 (40)
Part time	1 (20)	1 (20)
Unemployed	3 (60)	2 (40)
Income, n (%)		
Less than 15k	0 (0)	1 (20)
15K – 29.9k	0 (0)	0 (0)
30k – 49.9k	0 (0)	1 (20)
50K – 69.9K	1 (20)	0 (0)
70K – 99.9k	3 (60)	1 (20)
More than 100K	1 (20)	1 (20)
Not reported	0 (0)	1 (20)
Primary Earner	1 (20)	4 (80)

All women (n=10, 100%) had a computer at home and were comfortable (n=3, 30%) or very comfortable (n=7, 70%) using a computer, comfortable (n=1, 10%) or very comfortable (n=9, 90%) using the Internet, and comfortable (n=3, 30%) or very comfortable (n=7, 70%) using Smartphone/Tablet applications. Participants comfort level and use of the computer, Internet, and Smartphone/Tablet are reported in Table 3.

Table 3. Use of the Computer, Internet, and Smartphone/Tablet

Characteristics	Cycle 1 (n=5)	Cycle 2 (n=5)
Computer Use, Home, n (%)	5 (100)	5 (100)
Computer Use, Work, n (%)	2 (40)	3 (60)
Computer Hours/Week, mean (SD)	6.4 (2.302)	8 (.000)
Comfortable Using Computers, n (%)		
Comfortable	1 (20)	2 (40)
Very Comfortable	4 (80)	3 (60)
Internet Use, n (%)	5 (100)	5 (100)
Internet Hours/Week, mean (SD)	6.8 (2.168)	8 (.000)
Comfortable Using Internet, n (%)		
Comfortable	1 (20)	0 (0)
Very Comfortable	4 (80)	5 (100)
Smartphone/Tablet Application Use, n (%)	5 (100)	5 (100)
Smartphone/Tablet Application Hours/Week, mean (SD)	6.4 (2.302)	7 (1.414)
Comfortable Using Smartphone/Tablet Applications, n (%)		
Comfortable	1 (20)	2 (40)
Very Comfortable	4 (80)	3 (60)

User Performance

User performance was assessed through ease of use, efficiency, and observation of testing errors (i.e., navigation, presentation, control usage) through each scenario and cycle of usability testing. Overall, ten participants across two cycles of testing reported the overall usability of the *at heart* web-based application as highly acceptable (SUS mean 81.75, standard deviation [SD] 10.41). Nine (90%) participants rated the user-friendliness of *at heart* as good or excellent. All participants (n=10, 100%) thought *at heart* was easy to use and efficient (i.e., most women could learn to use *at heart* very quickly). "I think everything was pretty straightforward. It was overall really, really good" (Cycle 2, Participant 3). None of the participants indicated they would need the support of a technical person to be able to use *at heart* and eight (80%) of the participants found the various functions in *at heart* well integrated with minimal inconsistencies (n=8, 80%). "Well, … I was a bit worried it might be confusing, but it's not confusing at all. It's very intuitive, it, you've built it so it's similar to a lot of other apps out there, right? So, clicking here, you know, submitting the button. So, it seems to be pretty normal as far, it looks, the same look and feel as other apps that are out there which are good. It seems to be easy. I'm not a tech person, so I wanted to make sure that - I was nervous that I wasn't going to be able to manage it because I, I'm not great with technology, but it was easy. So, yeah. I mean, I think it's a great tool." (Cycle 2, Participant 5).

Testing errors included those related to navigation (difficulties moving through or locating content), presentation (selection errors due to labelling), and/or control usage (improper entry field errors) across the five scenarios in two usability testing cycles (Table 1). In Scenario 1 of Cycle 1 (Sign-In, Chatbot, Event Profile), participants reported low contrast between the text and the background and small font at sign-in (Table 4). Participants also wanted clarification that the Chatbot was not a real person. These were flagged as high priority and subsequent revisions included larger font, Chatbot and user text boxes identified using different colors, and a page was added to the *at heart* web-based application to describe the Chatbot, including its development and function. Specific text included 'let me tell you a little more about myself. I'm an educated Chatbot,

thoughtfully designed by a group of women's heart health experts. I'll be here to help you understand more about your heart pain/discomfort through regular check-ins, and I'll send you tips and tricks for managing that pain. If you want to learn more about my makers, the same ones who named me Holly, go to the menu above….' Participants selected only one descriptor on the body map and reported lack of clarity that more than one descriptor could be selected. The directions for completing the body map were enhanced. No navigation errors were observed during Scenarios 2 and 3 of Cycle 1, which assessed the workflow of the Chatbot-Guided Heart and Wellness Checks. Participants had difficulty locating the 'Favorites' section of the Library in Scenario 4 of Cycle 1. The 'Favorites' section was moved to the top of the screen and identified with a larger icon that represented a heart. No navigation errors were observed during Scenario 5 of Cycle 1, which assessed the functionality of Library Retrieval and Notes functionality. No other comments were made during this cycle of usability testing.

The scenarios were repeated in the second cycle to assess the performance and satisfaction of *at heart* across various Android and iOS devices (i.e., Smartphones/Tablets) (Table 4). In Scenario 1 of Cycle 2 (Sign-In, Chatbot, Event Profile), participants requested clarification on terminology used in some of the questions at sign-in (e.g., do you have or have you had any of the following: obstructive versus non-obstructive disease). Descriptors and additional answers were added to these questions. For example, for the question 'do you have or have you had any of the following…..? 'No, I haven't', 'I don't know' and 'other' button options were added for clarity and comprehensiveness. If 'other' was selected, follow-up instruction was included 'please specify your other heart related condition(s)' with a free text input field. Participants also had difficulty choosing specific areas on the body map to depict cardiac pain symptoms and radiation. The body maps were subsequently amended to include axillae and body map descriptors. In Scenario 2 of Cycle 2 (Chatbot-Guided Workflow for the Heart Check) participants appeared confused with the order and the speed of questions delivered by the Chatbot. The chat-timestamp was subsequently increased for desktop,

Android, and iOS devices. This allowed women ample time to read and respond appropriately to the

Heart Check questions, especially those with longer messages and prompts. Lastly, the Heart Check

button was reported to be too small and grey, "the size and grey colour made it hard to see".

Therefore, the size and contrast of the Heart Check button was adjusted. The Chatbot-Guided

Workflow for the Wellness Check (Scenario 3, Cycle 2) required minor adjustment to ensure that the

Chatbot selected appropriate resources from the Wellness Library based on wellness scores less than

or equal to 4. No navigation errors were observed during Scenarios 4 and 5 of Cycle 2. However, one

participant suggested 'anaphylaxis' be added to the 'Share My Data' section, which was completed.

It was also suggested that related articles be added to the Library, so lay summaries were generated

and scientific papers added to the Library for Kounis syndrome (n=3) and mast cell activation

syndrome (n=2). Participants also requested to have a more robust 'Share My Data' section, with

opportunity to record medications and other co-morbid conditions. The introduction and the content

of the 'Share My Data' section was enhanced. The introduction was amended to 'women's hearts are

affected by menstruation, pregnancy, and menopause. We are interested in collecting more

information on 1) socioeconomics (marital status, education, etc.), 2) risk factors (smoking, diabetes,

etc.), 3) gynecological/obstetrics history (menstrual cycles, pregnancies, menopause, etc.), 4)

lifestyle (physical activity, etc.), 5) medications, and 6) other conditions (arthritis, depression, etc.).

You can decide when and how much you want to share.'

Table 4. Summary of suggestions and subsequent changes during usability testing

	Suggestions	Changes
Cycle 1 (n=5)		
Scenario 1: Sign-in, Chatbot, Event Profile	Low contrast between the text and the background and small font at sign-in.	Larger font, Chatbot and user text boxes identified using different colors.
	Clarification that the Chatbot is not a real person.	A page was added to the **at heart** web-based application to describe the Chatbot, including its development and function.

	Participants selected only one descriptor on the body map and reported lack of clarity that more than one descriptor could be selected.	The directions for completing the body map were enhanced.
Scenario 2: Heart Check	None.	None.
Scenario 3: Wellness Check	None.	None.
Scenario 4: Library	Participants had difficulty locating the 'Favorites' section of the Library.	The 'Favorites' section was moved to the top of the screen and identified with a larger icon that represented a heart.
Scenario 5: Library Retrieval and Notes	None	None
Other:	None	None
Cycle 2 (n=5)		
Scenario 1: Sign-in, Chatbot, Event Profile	Participants requested clarification on terminology used in some of the questions at sign-in.	Descriptors and additional answers were added to questions for clarity.
	Participants had difficulty choosing specific areas on the body map to describe their symptoms.	The body maps were subsequently amended to include axillae and body map descriptors.
Scenario 2: Heart Check	Participants appeared confused with the order and the speed of questions delivered by the Chatbot.	The chat-timestamp was subsequently increased for desktop, Android, and iOS devices.
	The Heart Check button was reported to be too small and grey.	The size and contrast of the Heart Check button was adjusted.
Scenario 3: Wellness Check	The Chatbot says 'based on what you've told me, here are some topics….'. However, the Chatbot presented all topics, even for wellness scores that were excellent (i.e., the readings from the library do not appear tailored to the needs of each participant).	Minor adjustments were made to the rules to ensure that the Chatbot selected appropriate resources from the Wellness Library based on wellness scores less than or equal to 4.
Scenario 4: Library	None	None

Scenario 5: Library Retrieval and Notes	None	None
Other:	Add anaphylaxis to the 'Share My Data' section.	This was added.
	Add anaphylaxis articles to the library, as they related to women and heart disease.	Lay summaries were generated and scientific papers added to the Library for Kounis syndrome (n=3) and mast cell activation syndrome (n=2).
	Participants requested to have a more robust 'Share My Data' section, with opportunity to record medications and other co-morbid conditions.	The introduction and the content of the 'Share My Data' section was enhanced.

User Satisfaction

User satisfaction was assessed using themes that emerged from the debrief and four semi-structured interview questions: 1) what was your overall impression of the *at heart* web-based application? 2) What did you like/not like about the *at heart* web-based application? 3) Is there anything that could be improved or changed? and 4) Is there anything missing from the at heart web-based application? Eight themes emerged from the data: engaging, comprehensive, understandable, credible, relevant, affirming, personalized, and innovative (Table 5).

Engaging

Participants commented on the layout, visual appeal, language, and the name and logo of the web-based application. They found the content easy to read and maneuver. Important content was highlighted and participants reported this to be helpful. Article summaries were presented in larger font and used lay language. At the outset of this study, the web-based application was named HEARTPA♀N.[34] Participants recommended a name change to one that was less focused on pain, as many women describe their cardiac pain as discomfort and have other associated symptoms (e.g., dyspnea, fatigue, anxiety). They felt the name *at heart* was more personally welcoming and less

focused on pain. The heart logo was simple, yet distinctive and recognizable.

Comprehensive

Participants indicated that the web-based application provided necessary information for helping them make decisions about their cardiac symptoms. They liked that it was specific to women and that they could search through the library to improve their knowledge about wellness and women's heart health. Participants also commented that the Chatbot assisted them in making decisions, "the bot kind of identifies for me what the big blind spots are that I am perhaps not noticing".

Understandable

Participants indicated *at heart* was intuitive, the content made sense and it flowed well. The tone and the language were suitable and clear. Participants commented on the appropriateness of the associated symptom descriptors included in the Event Profile and the Heart Check.

Credible

Participants liked that *at heart* was developed as a living web-based application. They particularly liked the breadth and depth of scientific articles and lay summaries included in the *at heart* library. Participants valued having an evidence-informed digital health self-management program specifically designed for women with CAD living with cardiac pain and associated symptoms.

Relevant

Participants commented on the relevance and accessibility of locating content in the *at heart* library. The Chatbot asked relevant questions and was able to utilize rule-based algorithms to provide advice to women about timely assessment in the emergency department. They particularly noted the relevance of having their Event Profile and Heart Check information stored so that they could refer to these when visiting their healthcare provider(s). Content was applicable to their everyday lives.

Affirming

Participants looked for affirmation from *at heart's* Chatbot when they were having cardiac symptoms. They indicated they would have otherwise consulted with family members or Facebook group followers for guidance. Affirmation of symptoms was important to women and they appreciated the high alert messages to seek urgent care immediately.

Personalized

Participants liked the Chatbot. They found it to be personal, immediately interactive, accessible, calming, and friendly. They commented that the Chatbot may help them feel less alone if they went to the emergency room because it checked in with them to see how they were doing. The Chatbot provided comfort at times that participants felt scared. Participants also valued the videos and podcasts as they also helped them feel they were not alone in their experience with heart disease.

Innovative

Participants felt *at heart* provided an opportunity for further research focused on women's heart health. They were willing to share anonymized data on socioeconomics, risk factors, gynecological/obstetrics history, lifestyle, medications, and other conditions (arthritis, depression, etc.) to improve outcomes for women at risk or with heart disease. Participants also valued the ability to journal and take notes in the web-based application. They valued the opportunities *at heart* could provide to women who lived in more isolated areas or those who lived alone. The *at heart* web-based application was described as all-encompassing, covering necessary content to improve knowledge and decision making, with a Chatbot to ask questions and deliver information in a comforting manner.

Table 5. Summary of participant comments by theme

Theme	Quotes
Engaging: layout, visual appeal, language, and name/logo	"So good. And even just looking at the format…, it makes it really easy to read - the way it's spaced out and with the bullets and stuff." (Cycle 2, Participant 3). "I like the website. I find that the, just the layout of it is easy to maneuver. ... I can read it just the way it's laid out. … A lot of people will walk away from an app … if they get frustrated because it's too hard to figure out. No, this this seems quite laid out very nicely." (Cycle 2, Participant 3)

"It's highlighted in red, so it's hard to miss." (Cycle 1, Participant 1)

[Library] Well, this was helpful. … I like how they're [lay summaries] nice and big and then they're bold…." (Cycle 2, Participant 3).

[at heart] "…I like the name. … I like that it's not pointing at pain, but I like the simplicity of the name [at heart]. The other name that I really like that's in Canada is "heart life." There's just something about both of those phrases that just, I don't know, they just feel nice and they don't feel too sterile. I like the logo heart, too. It's a nice simple one, but it's very distinctive enough that you can recognize it. So, that was well done." (Cycle 2, Participant 1).

[at heart] "I like that it's a heart focused one … but this makes me feel like I'm personally welcome. Because it's specific to heart and it's getting at the heart of the matter, because I like that play on words. And that's my heart. How's my heart doing? And I like that you guys are moving away from the pain language." (Cycle 2, Participant 1).

Comprehensive: contains necessary information, assists in decision making

"I mean, I like this in being able to choose what I read. This way I decide what my problem is. The other way, the bot kind of identifies for me what the big blind spots are that I am perhaps not noticing." (Cycle 1, Participant 1).

"I feel like, how this does talk about 'what are your symptoms' and then they'll give you information based on how I'm feeling. I like that because sometimes I don't know what this means when I'm feeling this. And I don't want to tie up the medical system and go to emerg every time … So, you do have to be self-independent and try to figure things out yourself sometimes. So, I do like how this website is, gives me information. And you know, it says, 'go 911.' Absolutely. That's good." (Cycle 2, Participant 3).

"…I like the explanation about, you know, heart pain. And it's different depending … maybe I feel my heart fluttering and that's more of just a discomfort… , but it maybe, it's not painful. So that helps, that helps. You say OK, so include everything, like think about all the different things that might be happening in your body when you talk about your heart." (Cycle 2, Participant 5).

"I think people will be happy that there's something built for women. I think it actually calls out the items and the symptoms that are specific to women and I think it will help people and women understand that feeling heartburn might be an issue and it is a symptom…. it might help you understand the symptoms for a heart attack are very different than they are for a man. And that you should think about all of those if you are experiencing some sort of a pain. … I've seen people on … some of the Facebook groups say, '…You know, I'm having this issue, and I don't know what to do. Should I go to the emergency?' And, people are responding back to them, 'Go to emergency right away.' And to me that's more stressful. … So, if we can get this in front of them, that's what they're looking for, right. 'Here's my symptoms. Here's what I'm feeling. Oh, OK. This is, this bot, this is now telling me… I should

be concerned.' So, I'm going to go. I think I would, I would rely more on an app than I would of all these people … This is giving you some clear understanding of symptoms, what possibly you should do, and when it seems to be an issue that you should be looking into. So, I think it's, it's helpful." (Cycle 2, Participant 5).

[Library] "I am always curious, so I definitely would look through the library because I like to, I like to explore different options and do reading. I like to find - I definitely want to know more about my condition and stuff, right?" (Cycle 2, Participant 3).

Understandable: readability, lay language	"No, no I think that it is very intuitive. It makes sense to me and it reads well, it flows well, and I think anybody would understand it." (Cycle 1, Participant 2). [Chatbot] "It [tone/language] sounds good." (Cycle 2, Participant 4). "Yeah, I think that's clear. You explained the cardiac event, what it, when, you know, the signs, the symptoms the last time you were in the hospital or treated in the emergency department or told that you were having. Yeah, I think it's fair. I think it's a good question." (Cycle 2, Participant 5). "I'm thinking about when I actually had my heart attack right, and I'm starting to think about what were my symptoms at the time. And I think you've got some good words here. I had no pain in my heart during my heart attack. So, you know you have that category there, which is good …" (Cycle 2, Participant 5). "I think the question [about last cardiac event] makes sense. I think it's fair with the options that you've provided." (Cycle 2, Participant 5).
Credible: accurate, trustworthy	I mean, I would probably feel a little bit more justified in going with having been encouraged by the app because, you know, we're not making stuff up here, right? We're doing something that's more clinically supported, you know? So, as a user, I would feel more inclined to go [seek medical care]." (Cycle 1, Participant 4). "I feel comfortable that what it's saying to me is actually, reasonably well-researched and were going to be reliable information." (Cycle 1, Participant 4). "And I like that this is one of those things where I can see … it will be immediately helpful, but at the same time, after you've gotten feedback for a year, there will be even more things that you can tweak, and it's nice to see something that will be living and keep going and knowing that it's got real, local experts." (Cycle 2, Participant 1). "And that's nice touch. '... Real, genuine, expertise analysis.' This isn't some app that somebody who is going to sell me something... This screams, 'this is a legitimate researched, academically thought-out item.'" (Cycle 2, Participant 1). [Library] "… I really like how deep you're going with the library and the beauty of that is that this can really become the place. And with having the scholarly article, with the simplified summary on top. Like, that's building like the library that, frankly, the ER doctors… , the GP should go to because they're not going to take

the time, and need even the cardiologists, … to read the amount of articles I've read in the last few months on ## syndrome. But maybe at least if you … could go something like this and go, 'Oh. OK, I read the summary. I've at least got the basic concept. Let's go.' So, I think you guys are on the right track." (Cycle 2, Participant 1).

Relevant: applicability   [Library] "The other piece I was going to say was useful … is the articles. So, you know, if I had a question, it would be nice to come to some content I knew is actually quite reliable, and, you know, might give me things in a way that was really accessible." (Cycle 1, Participant 4).

"And I'll tell you, if I had known about these symptoms ahead of time… , I probably would have acted and not had to go through what I went through. But I didn't make the connection. I didn't make the connection of my heart palpitations are weird and that I can't breathe properly when I'm going up a flight of stairs, and that I have really bad heartburn, and I'm sweating. ... If I'd made the connections, I would not be here today as far as in this situation where I had a heart attack and had a stroke. Right. So, I think it's good and if you've already had a cardiac event, it's even more important that you manage, if something starts happening again, that you know to pay attention." (Cycle 2, Participant 5).

[Chatbot] "You're asking the right questions. I really like the fact that it asks for the symptoms that you experienced and then it brings up those symptoms again and it makes that connection. … It also brings up the things that are typically for women and not so much for men. I think it's good that it's specific for women because women are under researched and under diagnosed. …If I had known that there were four or five things, that would have meant I had a heart problem, I would have paid closer attention. … And I think the app's good because it helps you put in the symptoms you're feeling again and it'll make you feel like you're not being crazy, because sometimes you think, 'should I go to ER or not go to the ER? What should I do?' I feel like this and people are like, 'Oh, it's just nothing.' But if I put it in my app, and I've put in four or five things that I'm feeling and it says, 'oh, this is really close to what you experienced when you had your heart attack. You may want to really pay attention to this.' That's what I think is important." (Cycle 2, Participant 5).

"When you're panicking, and you're sitting in the hospital, and you're trying to remember all the things you need to tell ... the person in the hospital - you could pull up your app and say, 'OK, so here's all the things,' right? Cause it helped you." (Cycle 2, Participant 5).

[Chatbot] "When you got all that heart pain, you need someone almost to guide you through the things that - or something you normally don't even think about, they're just natural abilities. So, it's kind of nice to tell someone - to tell [remind] me what to do [take nitroglycerin as prescribed]." (Cycle 2, Participant 3).

Affirming: symptom   [High Alert Message] "I think it's actually excellent. She doesn't

recognition		know what to do, she doesn't want to go to the hospital. That's why someone is looking at an app – because you are wanting the app to tell you something different than what's happening and you want confirmation, so I think that this is good. The app says you need to call 911 so hopefully she does." (Cycle 1, Participant 1). [High Alert Message] "I thought that it made sense. It highlighted that you need to seek urgent care immediately based on what they had reported and then it tells you how to go about doing that and it reminds you why you are going to the ER … what's happening and why you're going. It covers all the bases." (Cycle 1, Participant 2).
		[High Alert Message] "I like that. Not for my situation, because I seem to - but I noticed that a lot of people don't know what to do. Then they go into panic and then they're - I don't know if you've seen that on the Facebook sites, so they start panicking and asking people, 'what I should do.'" (Cycle 2, Participant 3).
		[High Alert Message] "I'd probably be calling a family member or somebody. I would probably be following what you're saying, right? Calling 911. Yeah, that's a tough one because it's actually, it shows exactly what happened when I had my heart attack the first time and the only thing that made me call 911 was actually the fact that I couldn't breathe, which I didn't put down for this one, right. So, … what you're saying is, this is close to what happened to you before, so you should really pay attention to it. So, I think it's a fair assessment." (Cycle 2, Participant 5).
Personalized: support	social	[Chatbot] "But I think that actually the bots do quite a good job because we thought they were real until you guys told us that they weren't." (Cycle 1, Participant 1). [Chatbot] "I just found it makes it more personal too. It feels like you are talking to a person and filling in fields and links and stuff." (Cycle 1, Participant 2). [Chatbot] "It's sort of a really familiar way to kind of get asked a series of questions for someone who's used to sort of chatbots or texting or stuff like that. So having it be an interactive kind of thing is great." (Cycle 1, Participant 4). [Chatbot] "I like the tone. It just feels accessible, it feels friendly, and when somebody is either want or wanting to learn something or is feeling scared, those kinds of thoughts, that's the tone that I would want." (Cycle 1, Participant 4). [Chatbot] "I really love the bot feature. I think that's a real strength as it's immediately interactive, rather than, a lot of the times you can choose the bot or not. And I think with this, it's a really good way to go with it because it makes it really interactive and I think that's important, and it's gathering some data of the user." (Cycle 1, Participant 5). [Chatbot] "And for some people, if they're really bad and they've got to go to the ER - some people are very, very alone. So even though this is a Holly robot, it's not a bad thing that Holly's going to reach out and say, 'hey.' An hour later, 'How are you doing?', because maybe Holly's the only one who's going to reach out and do that. And there's still some comfort. It's not, in some ways, that

different from when I, at different times, I'd be actively messaging one of my heart groups online. If there was something so frustrating in the ER, I've got to share it with somebody and Holly could serve that purpose for some people. So, I think it's - it wasn't in pieces I expected, but I think it's interesting." (Cycle 2, Participant 1).

[Videos] "… I definitely enjoy, like Donna's story here. I'm assuming that's her life experience having the condition. I actually enjoy reading things like that. You help relate, it helps to - you're not the only one, and then you relate to how someone else is feeling. And it, I like reading things like that. I think those are really good to have." (Cycle 2, Participant 3).

[Chatbot] "But, when I'm in that state of mind and I'm dealing with the chest pains, I'm dealing with that, I actually like to be walked through things. It's a calming. 'Is that OK? Do this. Do this.' And it actually helps. That is actually a really good way to do things." (Cycle 2, Participant 3).

[Videos/Podcasts] "No, I love the videos [personal testimonies]. Those are good." (Cycle 2, Participant 3).

Future-Oriented: research, women's heart health

"I think there's a lot of women on non-obstructive side, who would do this for sure. So, I think you'd get a lot of people saying, 'well, yes, please study us, analyze us and figure us out.'" (Cycle 2, Participant 1).

"So, it becomes a place where I can do my own tracking, even if I don't want to do a Heart Check or a Wellness check, I can come in here and make notes and keep it in a contained spot." (Cycle 2, Participant 1).

"I do like it and I think having women who are isolated… , they don't have access to medical care that people in the GTA would have. I think it's excellent for that population because for them getting to see a doctor or getting to the hospital may not be as easy for them as it would for me. People who are living and have a limited income, taking the ambulance in Ontario costs $45, and that might be $45 someone doesn't want to spend. So having an app tell you need to go and you need to call 911 could be a deciding factor for them and it gets them going, as opposed to not doing anything, so I think that's a good target group." (Cycle 1, Participant 1).

"I found it fairly all-encompassing. … It made me comfortable answering those questions and looking forward to the information it was going to provide, so that I could see if there is something in there to educate myself on the problems and why I was experiencing the symptoms I was experiencing, et cetera, and what I should do about it. I just found it comforting, you know, giving you access to education that not everybody would know where to find or start looking for. By being able to search even the meaning of a word in the context of an article, it would just make it much easier even when you went to speak to your physician to have something back you up rather than just hoping they understood what you were saying or hoping they read the same set or articles

or have access to the same body of knowledge." (Cycle 1, Participant 2).

Yeah, I would for sure still use it." (Cycle 1, Participant 5).

Discussion

There is growing support for the importance of usability testing for mHealth and eHealth innovations.[53-55] Usability testing incorporates an iterative process of testing and refining to meet end-user needs.[56] The goal of this study was to conduct usability testing of the novel *at heart* progressive web-based application to ensure it was easy to use, efficient and satisfying. *at heart* is the first of its kind; no smartphone or web-based self-management program has been co-designed and systematically developed with women who have lived experience, and then tested with women who have cardiac pain. We used the individual and family self-management theory,[57,58] mobile device functionality and the pervasive information architecture of mHealth interventions,[59] and followed the Medical Research Council (MRC) guidance for developing complex interventions.[60-62] Three core features including a Heart Check, Wellness Check, and a Library with a virtual interactive Chatbot to manage *at heart's* content and conversations were assessed during two cycles of usability testing focused on user performance (ease of use, efficiency, and errors) and satisfaction.[63]

The overall usability of the *at heart* web-based application was rated as highly acceptable; it was easy to use and efficient. Two high priority testing errors were identified during the first cycle of usability testing: low contrast/small font and clarification that the Chatbot was not a real person. The *at heart* Chatbot is a simple rule-based conversational agent designed to mimic human-to-human interaction at sign-in, creation of an Event Profile, and during completion of Heart and Wellness Checks. Our previous systematic review and meta-analysis indicated that self-management programs were more effective in reducing cardiac pain and associated symptoms (e.g., dyspnea) in women if they included collaboration/support from healthcare providers (standardized mean difference [SMD], -0.57; 95% CI, -1.00 to -0.14).[38] Chatbots are conversational agents, able to promote health and provide education and support.[64] Their use in healthcare in still in a developmental stage, they could

improve access to care and healthcare provider to patient communication but more evidence is needed. Technical, design (i.e., lack of empathy), and language challenges[65] can impede the integration of Chatbot technologies into healthcare;[64] however, adopting user-centred and theory-based designs, optimizing user experiences, and addressing patient concerns can improve their uptake and utlization.[64] We committed a significant amount of time to addressing potential language challenges during the development of the Chatbot and there were no technical, design or language challenges identified during the usability testing cycles. In fact, the design and language/conversation of the Chatbot appeared to mimic the human-to-human interaction so closely that participants requested confirmation that the Chatbot was actually non-human. Our Chatbot relies on scripted computational algorithms, with specific rules for its text-based conversations.[66] More advanced human-machine conversation is now based on natural language processing and large language models that use artificial intelligence methods to learn, understand, and produce structured language content.[66,67] Healthcare delivery is rapidly changing and is driven by social, scientific and technological change; our future Chatbot may need to emulate person-to-person conversation through dialogue, body movements, with appropriate expressions of empathy and compassion.[68] We are really at a cusp in healthcare; growth in Chatbot use will be driven by a desire for health and wellness and 24-hour access to care with a growing number of platforms from which to build an intelligent and emotive Chatbot in the future.[69]

This study also identified that the comprehensiveness and credibility of the information was important to women. It helped them to understand more about heart disease/wellness and provided them with guidance in decision making. Women have a varied pattern and distribution of cardiac pain symptoms; they describe cardiac pain as sharp and burning, with additional symptoms of discomfort in the jaw and shoulders, breathlessness/dyspnea, anxiety and extreme fatigue/tiredness.[70] This varied pattern and distribution of symptoms make it difficult for women to interpret pain as cardiac-specific.[70-72] Women minimize their symptoms, prefer to consult with family and friends,

have caring responsibilities and concerns for their family[73]. As a result, women delay seeking appropriate care for their cardiac pain.[74]

At inception, women clearly articulated the need for a web-based application that was accessible across Android and Apple's iOS operating systems, including computers, smartphones, and tablets. They wanted to access the library anytime and anywhere (e.g., while waiting for dental appointments). As women were involved at the outset, no other significant user-performance or satisfaction-related issues were identified. Female front and back full body maps were specifically developed for *at heart*, using the chest pain and/or associated symptom locations most commonly described in the literature.[6,8,13] These required only minor refinement during usability testing (i.e., more precise identification of the axillae). Importantly, participants also viewed *at heart* as a way to contribute to the future of women's heart health. Women feel "stopped at the gate" and they want to take charge and advocate for better awareness, education, diagnosis, and management.[75]

Limitations. First, usability testing was conducted on a homogeneous sample of participants, which could limit the generalizability of our results. Sixty percent of the participants who participated in usability testing earned greater than $70,000 Canadian dollars annually, they were well-educated, and most were White. Canada is known for its diversity in race and ethnicities, more than 450 ethnic or cultural origins were reported in the 2021 census.[76] One out of five people in Canada is born elsewhere; the 3 largest visible ethnic groups are South Asians, Chinese and Blacks – representing 60% of the Canadian racial and ethnic populations.[77] Although this was a limitation in the sample for the usability testing, this is not a limitation specific to the *at heart* web-based application. In fact, the *at heart* library contains heart disease and heart wellness scientific papers and lay summaries related to South Asian and Indigenous People. These include risk and traditional practices such as drumming and healing/talking circles. Further research is needed to evaluate the usability of the at heart web-based application across various race and ethnicities. Second, the *at heart* Chatbot is rule-based and designed for specific functions within the progressive web-based application. It is not led by artificial

intelligence technologies (i.e., natural language processing or large language models) and therefore may have inherent limitations that were not identified during the two cycles of usability testing (i.e., personality, flexibility, dialogue structure, and conversation complexity/flow).[65]

This study does provide strong initial support for the *at heart* web-based application for women living with cardiac pain and cardiac symptoms. Findings from the second usability testing cycle will be used to refine the prototype prior to the pilot randomized controlled trial aimed to: 1) examine the feasibility of randomization, recruitment and retention; acceptability and barriers to implementing the intervention (including the symptom triage algorithms); and the extent of engagement with the intervention; and 2) undertake a preliminary efficacy evaluation of our primary outcomes of pain and health-related quality of life.

Acknowledgments

Conflicts of Interest

None declared.

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Abbreviations
SUS: System Usability Scale
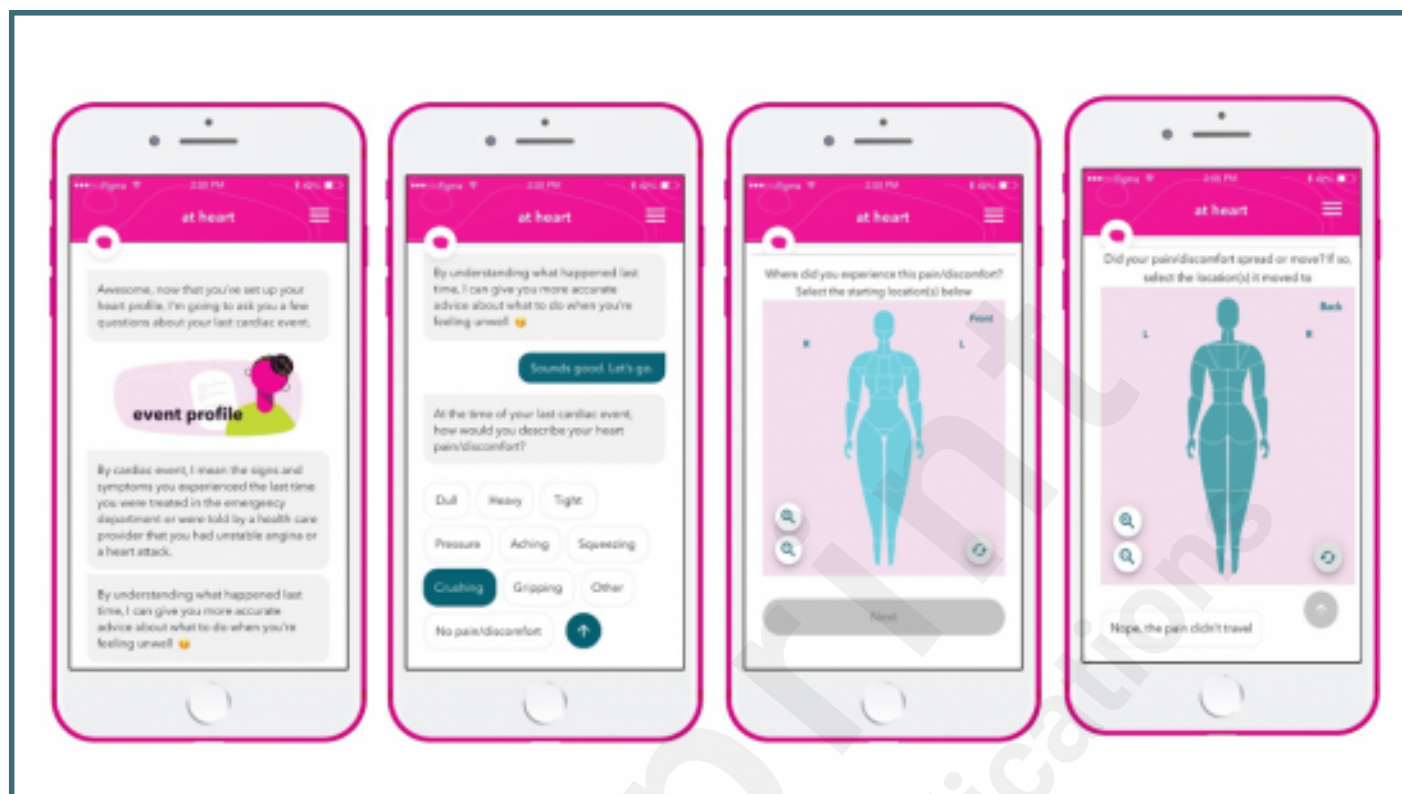
Figure Captions

Figure 1. *at heart's* Event Profile.

Figure 2. *at heart's* Heart and Wellness Checks.

Supplementary Files

Figures

at heart's Event Profile.

at heart's Heart and Wellness Checks.