Design and Testing of a Mobile Cardiovascular Risk Service with Patient Partners

Final Report

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Structured Abstract

Purpose: The objective was to develop and test a mobile app-enabled, pharmacist-managed centralized cardiovascular risk service (CVRS) for implementing evidence-based guidelines.
Scope: Ischemic heart disease is the number one cause of mortality among adults in the United States.[1]
Methods: We partnered with adults with cardiovascular risk (age 55+) in four sessions to obtain design guidelines, tested prototypes in three focus groups and tested the final version of the native mobile app plus web app compared with the web app alone in a four-month 1:1 randomized single-blind controlled trial. Medical record abstracted data alerted pharmacists in both study groups to guideline metrics in need of attention. Log-tracking measured patient engagement.
Results: Study groups were balanced at baseline and participants used the engagement features (present in native and web app versions): in-app health assessment was used by 89% of patients, health data entry was used by 74%, and pharmacist messaging was used by 81% of patients. Engagement was similar between study groups (mean 9.7 vs 8.8 days of system interaction, p=0.62; median 8.5 vs. 6.5, p=0.41) and a mean of 4.8 vs. 3.1 (p=0.06) days of messaging pharmacists (median 3.5 vs. 3.0, p=0.11) for the native+web app vs web app group. The differences were less than the trial was designed to detect (5 to 10 days), attributed to similarity of the interventions and overall high engagement. A novel, mobile app-enabled centralized pharmacist managed CVRS, created with patients as partners, successfully engaged patients in risk reduction discussions based on evidence-based guidelines.

Key Words: Personal health record, health promotion/methods, pharmacist patient relations, mobile health (mhealth), usability, patient communication, patient engagement

Purpose

This study was conducted under RFA-HS-14-010 “Disseminating and Implementing Evidence from Patient-Centered Outcomes Research in Clinical Practice Using Mobile Health Technology.”[2] The purpose of this study was to evaluate the impact of adding a native mobile app on patient engagement in a pharmacist-managed evidence-based cardiovascular risk service (CVRS) for improving cardiovascular disease (CVD) management. The specific aims were:

Aim 1: to implement user-centered design methods to partner with mobile health (mHealth) technology users in the design of a native mobile app for disseminating a pharmacist-managed evidence-based CVRS into practice.

Aim 2: to examine the feasibility of mHealth technology to disseminate evidence-based risk reduction guidelines in a prospective randomized controlled trial among diverse primary care offices.

- Primary Hypothesis: Patients randomized to the intervention group (native mobile app and CVRS web site available) will interact more with the system (as measured by mean number of days interacted, mean contacts with CVRS pharmacist) than patients randomized to a control group that is only given access to the CVRS web site.
- Secondary Hypotheses:
  a. Mean number of days of system interaction and mean contacts with a CVRS pharmacist will be significantly greater in under-represented minorities randomized to the intervention group compared to the control group.
  b. Mean percent of guideline metrics met at 4 months will be significantly greater in intervention compared with control group patients.

Scope

Background and Context

An American Heart Association (AHA) report states that "…more than 2,200 Americans die of CVD every day… 1 death every 39 seconds."[3] The cost was $286 billion, or 15% of total healthcare expenditures.[4] Stroke is the third leading cause of death; someone died every 4 minutes[3] and will cost over a trillion dollars from 2005-2020.[5] Only 21-47% of women with ischemic heart disease or diabetes received recommended therapy.[6] We have found major regional and age variations in guideline concordant therapy following MI.[7-13] These gaps are often associated with busy primary care providers who often must address acute presenting complaints for patients with multiple chronic conditions. Medication regimen complexity markedly reduces adherence.[14] The contribution of the present study is: 1) the development of an mHealth strategy for a CVRS to improve the management of CVD, and 2) determining feasibility to achieve key performance improvement measures[15] by using it to interact with a centralized, pharmacist-managed CVRS. We expected the study to produce the following outcomes: enhanced features for and engagement with a CVRS and increased achievement of guideline-concordant therapy. These findings would be significant because there could be 20-30% fewer coronary deaths and 25-40% fewer stroke deaths in the U.S. if our CVRS intervention is widely implemented.[3,16] This study could meet important targets in the NHLBI strategic plan, the Million Hearts Campaign, the American Cancer Society (ACS), the American Diabetes Association (ADA) and the AHA as outlined in the Guideline Advantage program. The results of a web-assisted, remote pharmacist intervention were recently reported by our team.[17] The intervention was successfully delivered to patients for 12 months, with modest improvements in guideline adherence and risk factors.

Optimal CVD management requires patient involvement in self-management including medication adherence and monitoring their health status. Patients need information, reinforcement, and support to achieve this. Time available during clinic visits is insufficient and traditional printed self-help media are not individualized. mHealth could be important for providing individualized support between physician visits including when patients are "on the go." It has the added advantage of being more accessible than a regular website for patients who primarily access the Internet for personal use through their mobile devices. There have been numerous systematic reviews of mHealth,[18-29] and even the most recent[18,19] have found that there is: (1) insufficient high quality evidence of beneficial effects on clinical outcomes to warrant implementation of mHealth tools for disease self-management; (2) available tools include a limited range of behavior change techniques and many are uni-faceted, signaling a need to incorporate for mobile delivery additional components found effective in other self-management interventions; and (3) many apps were not evidence-based. **A gap in the mHealth literature that this study addressed** is that no trial has incorporated communication with a pharmacist.

Settings and Participants

Specific Aim 1 - Participatory Design and Usability Testing

Testing took place in three steps and with several different samples.

Step 1. In-person user-centered design sessions. Participants were recruited through a sample drawn from the Seniors Together in Aging Research (STAR)[30] volunteer research registry administered by the Center on Aging at the University of Iowa. Eleven participants attended a series of 4-90 minute design sessions, held at a conference room on the U of Iowa campus. Study inclusion criteria were: (1) age 55 or older, (2) report at least one medical inclusion criteria for the feasibility trial (see Aim 2), (3) uses a smartphone to search the Internet at least weekly, and (4) in the past 10 years was not an IT or health professional. Participants ranged in age from 63 to 77, two were women, and all but one had a 4-year college degree. Hours using a smartphone to access the web ranged from 1 to 25 per week.

Step 2. Formal usability testing. Thirteen people participated in one of three 90 to 120 minute usability sessions. Participants were recruited from the STAR registry or patients from the University of Iowa Family

Practice Clinic and met the same inclusion criteria as for the design sessions. Participants (7 men, 6 women) ranged in age from 58 to 80 (median age 69) and 9 had 4-year college degrees. Hours using a smartphone to access the web ranged from 0 to 90 (median 11 hours). Seven people had ever installed an app on their smartphone. Eight used an iOS device, 2 Android, 1 Blackberry, 1 Windows and 1 did not know their smartphone operating system.

Step 3. Brief field test. Three men and one woman who had previously participated in either the design or usability sessions were recruited. Each participated in two individual meetings so staff could observe them download the app and complete tasks without support, work with the app at home for a week, and return for debriefing of their experience.

Specific Aim 2 - Trial Participants

Study Inclusion and Exclusion Criteria

English-speaking adults, ages 55 years and older, who previously received care at one of the primary care practices in the past 18 months were identified using an electronic search of medical records. Eligible patients had a history of at least one of the following inclusion criteria: (1) most recent hemoglobin A1c (HbA1c) > 8.0%; (2) low-density lipoprotein (LDL) ≥ 100 mg/dL; (3) most recent blood pressure ≥ 140/90 mm Hg (150 mm Hg if age ≥ 60) or diastolic blood pressure (DBP) ≥ 90 mm Hg; (4) history of myocardial infarction (MI) or ischemic stroke not taking antithrombotic or aspirin therapy; (5) history of ischemic stroke or myocardial infarction (MI) not receiving statin therapy; (6) history of MI in the previous 3 years not taking a beta-blocker; (7) history of MI not receiving an angiotensin-converting enzyme (ACE) inhibitor or angiotensin II receptor blocker (ARB); (8) diagnosis of diabetes not taking an ACE inhibitor or ARB; (9) diagnosis of diabetes without urine microalbumin screening performed in the prior 18 months. Patients were excluded for the following criteria: (1) most recent SBP ≥ 200 mm Hg or DBP ≥ 110 mm Hg; (2) history of significant hepatic disease including cirrhosis, chronic hepatitis B or C, or have current elevated liver function enzymes (serum ALT or AST > 3 times normal); (3) history of hemorrhagic stroke; (4) diagnosis of primary pulmonary hypertension; or (5) stage 4 cancer.

Recruitment

Four primary care clinics from two health systems participated in the study. To identify participants for the trial, we identified eligible patients from structured data elements in electronic medical records at participating clinics as described above. A total of 1,452 patients were sent invitations. Study invitation packets included a cover letter on clinic letterhead, co-signed by the site lead clinician(s) and the study PI, and a study brochure. The cover letter briefly described the study and invited recipients to download the free study app and login with the unique username and password provided. The brochure expanded on the purpose of the study and login process. Of 1,452 people invited to participate in the trial, 80 enrolled (40 in each group).

Methods

Study Design and Data Collection

Specific Aim 1 - Participatory Design and Usability Testing

Design Sessions. The purpose of these 90 minute sessions was to elicit features desired for a mobile CVRS system. We began each design session with a description of what we hoped to accomplish, and by fielding questions about those activities. Thereafter, attendees would break into small groups, facilitated by research team members, with the session moderator floating between groups. In small groups, participants would generate ideas through discussion on the topic at hand. The groups recorded ideas using "sticky notes" which the facilitator collected and clustered visually on a whiteboard. Toward the end of each session, the full group reconvened to share and explore ideas from the smaller groups. A team member recorded detailed notes on all full group discussions. Following each session, research team members met to distill concrete design parameters for developing the app. In between meetings, the team further explored and discussed session highlights and key themes to guide the next session's topic. We began with a very broad session to encourage 'outside the box' thinking and subsequent sessions were progressively more focused. For instance, in the first session, groups of 2 to 3 participants were asked to imagine, draw and describe a magical being that followed them around and helped with their health care and consider what sort of powers it would have if these were unlimited. The next session itemized 30 possible features from this exercise and asked participants to individually select the five they would most want to keep and the five that were least important.

Usability Sessions. We obtained feedback on early app prototypes by convening three focus groups with patients with characteristics of intended users. Participants were given log-in credentials and a task list. Tasks included going through the enrollment, registration, and health assessment portions of the app and then exploring the app by adding medications and entering and editing blood pressure measurements. After completing each category of activity, participants completed a task load index questionnaire.[31] The process of eliciting feedback on prototypes and distilling findings from the sessions mirrored the approach used in the design sessions. Discussions were more directed and less exploratory as the goal was to elicit feedback on specific prototypes presented to attendees rather than to explore design features.

"Field" test. For the first meeting (15-30 minutes long), after providing informed consent, participants were given a sample letter from the trial and asked to download the app onto their phone without assistance. Study staff left the room and checked back in within 5-10 minutes to see how they were doing. After the app was downloaded, a task load index[31] questionnaire was completed and they were invited to talk about any issues they had downloading the app. Next, the participant was given a general task list to follow over the next 7 days. These are tasks that would be expected to occur in the eventual trial. Participants returned for a 30 to 60 minute exit visit approximately one week later. The total time spent using the app daily was up to the participant.

Specific Aim 2 - Mobile app Trial

The feasibility trial ("Iowa PHR Pharmacist Connection Study") invitation provided directions for downloading the study app from the App Store (iOS) or Google Play (Android) and provided unique login credentials. Upon (free) download, electronic consent was administered through the study app using Research Kit (iOS) or a similar application we custom-programmed for Android devices. Name, date, and signature for consent were automatically stored in the research database whereupon users next completed a brief enrollment ("registration") form. The app then immediately randomized them 1:1 to seamlessly continue with either the native mobile app or the web app accessed via smartphone. From the users' perspective, they were enrolled and randomized all at once when they submitted the registration form. Thus, all study participants initially joined the study by downloading an app that was used for purposes of enrollment and, subsequent to randomization, continued their study experience in-app. The native mobile app group

continued to use the native app with the option (via link on the app's menu) to use the web app; the web app group was automatically routed to the web app. See 'Interventions' section below for a description of feedback provided to users during their use of the app and about how the app was used to engage with study pharmacists. The study flow diagram (Figure 1) displays the detailed flow through the study (Full-size Figure 1 available on the study web site (*see "Flow Diagram"*)).

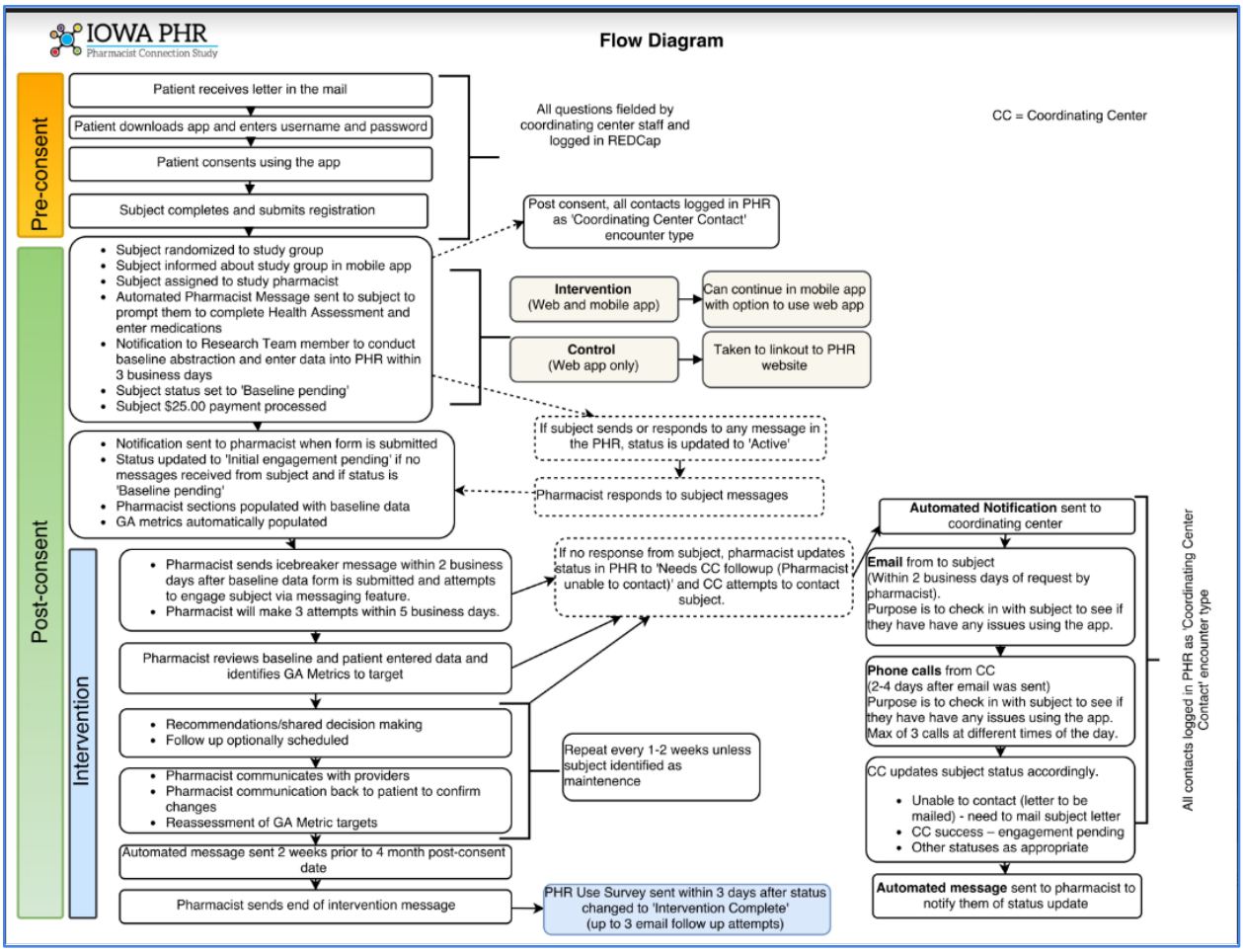

Figure 1. Study Flow Diagram

Data collection included medical record abstraction and log-tracking of system use. Medical record abstraction occurred at the beginning of the intervention covering the 18 months before enrollment and again at the end of the 4-month intervention period. System use and navigation data for trial participants were logged automatically throughout the study period. The system generated timestamps for logins and interaction with select features within the app. Other data available for evaluation include data from a health assessment questionnaire that was provided in the app for use by patients as part of the pharmacist-patient interactions. Description of the pharmacist consultations was also collected through the study pharmacists' use of the clinician interface (not visible to patients) to record their encounter notes and recommendations to clinicians in response to their evaluation of patient status on Guideline Advantage (GA) metrics.

Interventions

Description of the native and web app features

The native+web app study group could access both the native app and the full website (available through a link on the native app home page) and the web app group could only access the website version. The native and web app offered the same core functions. Users could continually add and edit personal health data (e.g., blood pressure, blood sugar, cholesterol, conditions, etc) and maintain a current medications list. Users were prompted by study pharmacists to complete a health assessment through the app and their

results produced an immediate list of recommendations about what they could do to improve cardiovascular health and a reinforcement of positive steps they were already taking. For both groups, new messages from study pharmacists were indicated to patients with a new message bubble in the system. In addition, in both groups, email notifications were sent when users received a pharmacist message or reply. An electronic copy of the signed informed consent document was made continually available to study participants in the native app as well as the web app. The web app also included PDF reports of data the patients had entered. Both study groups could access the website (web app) to view, save, or print these reports.

The home page and health assessment menu for the iOS and Android apps are displayed in Figures 2 and 3 below, respectively. Figures 4 and 5 contrast the view of the health assessment as seen from the iOS native app and the web app as accessed through a mobile device. The primary differences between study groups were the user interface and that users in the native app group had the ability to receive notifications on their mobile devices. As with most mobile device notifications, users had the ability to turn off app notifications in whole or in part. Some features were available only to users of the iOS app. These include ability to use some features when offline (e.g., view health assessment responses and recommendations, watch the introductory video, view the consent document and study information and prior answers to health assessment questions), and receipt of reminders to users who started but did not complete the enrollment or did not submit the health assessment after enrollment. The iOS app also contained a series of 3 screens designed to provide users with a quick tutorial on how to enter information in the app.

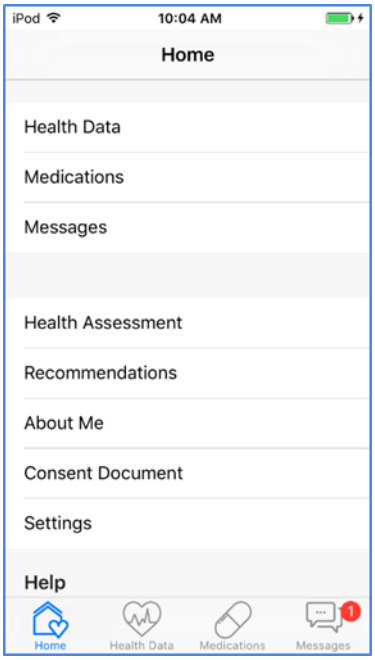

Figure 2. Home page for the iOS study app

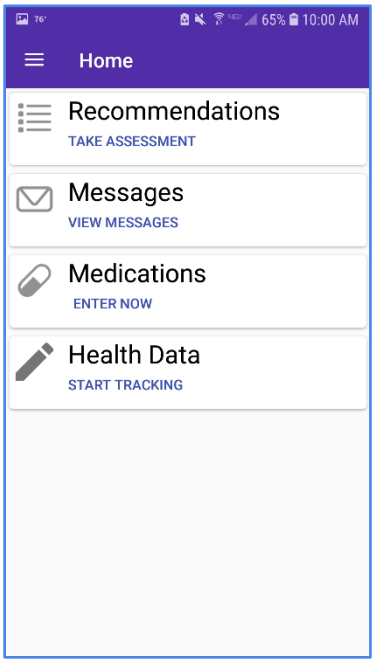

Figure 3. Home page for the Android study app

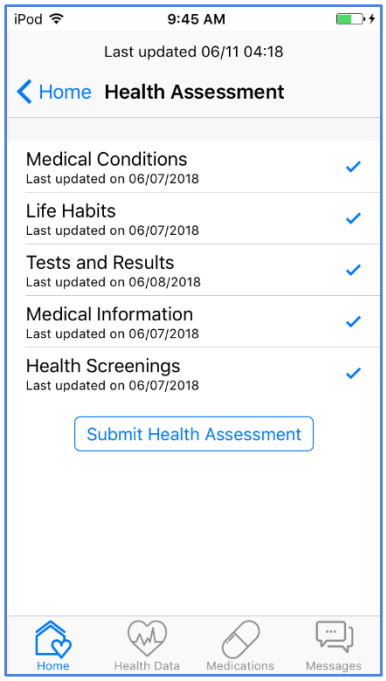

Figure 4. Health assessment menu as it appears through the iOS study app

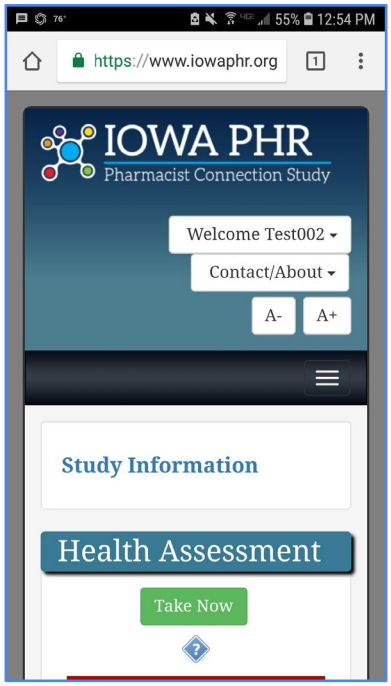

Figure 5. Health assessment menu as it appears on the website when accessed by smartphone

Description of the Intervention

Within three business days after randomization, the study medical record abstractor abstracted data from electronic medical records onto paper forms and data were entered into the PHR database (Figure 1). Pharmacists were notified via email when the data were entered into the PHR for a patient, and could access a view of the entered data. An electronic algorithm processed the medical record data and automatically generated a pharmacist view that listed each guideline metric requiring review for that patient. In both study groups, the study pharmacists provided consultations and recommendations for changes based on the guidelines (Table 1). Pharmacists did not make independent treatment changes but made recommendations to the participant's provider. Pharmacists also conducted an initial medication reconciliation between patient-entered medications and the electronic medical record. Study pharmacists were required to have a Doctor of Pharmacy (PharmD) degree and a minimum of 1 year of clinical residency (or equivalent practice experience). They had extensive experience with direct, face-to-face management of chronic medical conditions, including diabetes mellitus and cardiovascular disease in collaboration with primary care physicians.[17]

Table 1. Activities of the study pharmacists (See Figure 1 for Detailed Flow of Intervention)

1. Initiate and respond to patient requests for consultation;
2. message every 1-2 weeks to engage patient unless patient classified as 'maintenance';
3. conduct assessment and counseling for medication adherence, side effects, exercise, CHD knowledge, weight, diet, tobacco use and alcohol use;
4. develop an action plan that addresses gaps in guideline-concordant therapy, update medication list and record recommendations for medication changes or preventive care in the electronic medical record or occasionally via email to the primary physician;
5. follow-up to determine if plan was accepted and ensure implementation; and
6. document all patient and provider encounters in the PHR database

Measures

Specific Aim 1 - Participatory Design and Usability Testing

In addition to the qualitative approach described previously, we administered an modified version of Hart and Staveland's NASA Task Load Index[31] to evaluate the level of effort required to use early prototypes of the native apps. Participants completed the Index to assess workload on five, 7-point scales (mental demand, physical demand, performance success, effort, and frustration) with 21 gradations each ranging from very low to very high demand.

Specific Aim 2 - Mobile app Trial

Table 2 lists the primary and secondary endpoint measures, covariates, and process measures, their source and when they were collected.

Table 2. Data elements, sources and timing.

Data Element	Source of Information	Baseline	4 Mo.
Primary Endpoints			
Patient interaction with system (mean # of days interacted, mean contacts with pharmacist)	Log tracking		X
Secondary Endpoint			
Percent of guideline metrics met	Pharmacist recorded end of study status*	X	X
Covariates and Process Measures			
Age, race, sex, weight, BMI, education level, economic status, marital status, insurance, general health status	Health assessment /Medical records	X	
Co-morbidity (chronic conditions)	Medical records	X	
Number of chronic medications	Medical records	X	
Medication adherence, smoking status, diet, physical activity	Health Assessment	X	
Allocated stage of change	Health Assessment	X	
Content of pharmacist recommendations	Encounter forms		X
Number and types of features used, percent who enter data, percent who complete enrollment survey, percent who stop early	Log tracking		X

* To assess GA metrics met we relied primarily on the pharmacist notes rather than medical records because the follow-up period (4 months) was too short for most patients to have visited their primary care physician in that time. For each GA metric flagged for review for a patient, the pharmacists coded the resolution as follows:

1. **Complete** (actionable metric, pharmacist executed full plan of work for this metric)
2. **Incomplete** (actionable metric, pharmacist not able to fully execute their plan of work for this metric)
3. **Met at baseline** (after review of all available information the pharmacist found the metric was already met, no pharmacist work plan was needed or executed)
4. **Not applicable** (e.g. patient never smoked so smoking cessation metric is not applicable)
5. **Unable to assess** (not enough information to assess whether metric applies, e.g., patient did not engage, withdrew, etc.)

For actionable metrics (those cases marked 'Complete' or 'Incomplete'), pharmacists recorded whether a recommendation was made to the patient, health care provider, both, or neither. When a recommendation was made to a provider, pharmacists recorded whether the recommendation was accepted.

Limitations

Limitations of our study include the small sample size, limited diversity of our participants, and short intervention period. Our findings are mostly from Iowa residents and may not be fully generalizable to other geographic locations. The duration of the study was designed to be sufficient only to assess uptake of and early engagement with the intervention as this is crucial for feasibility of a longer-term intervention. This duration may have been sufficient for patients and pharmacists to initiate a relationship and develop a short-term action plan, but not to fully implement and follow-up with the plan.

Results

Design Sessions

Figure 6 displays an example drawing from the first design session where the purpose was to elicit as many features that the design partners could imagine. In the second session (Figure 7), participants sketched communication features with providers, designing the look of the messaging interface to resemble a smartphone text conversation, and a menu or tabs to select what you want to do.

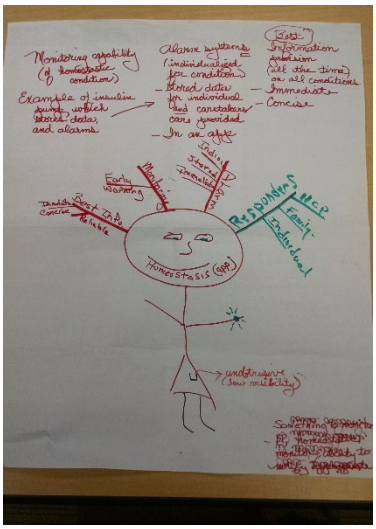

Figure 6. Session 1 design partner small group drawing

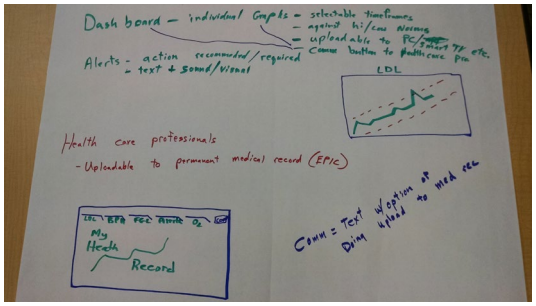

Figure 7. Session 2 design partner small group drawing

From their drawings, they identified 30 features and ranked those that they would like for an 'on-the-go' app (Table 3). After the ranking exercise, features were prioritized for development that would best support patients to interact with a study pharmacist. The design partners were interested in a device that provided a convenient way to track and send health data and that could monitor them constantly and alert others if something happened to them. In later sessions, design partners reviewed early prototypes for navigation and to provide preliminary insights on likely usability issues. Primary lessons included numerous early navigation issues to correct and the need to incorporate active outreach from study pharmacists to patients to alleviate skepticism that it would be possible to message a pharmacist and receive a response.

Table 3. Features identified for a mobile app and their priority ranked by users

Feature	Number who Indicated Wanting the Feature	Number who Indicated Not Wanting the Feature
….. a convenient way to measure, track, and send information such as blood pressures or blood sugars	7	1
….a way to alert first responders if serious emergency	4	0
….a way to let family and others know what's going on, caregivers can access stored data	4	1
….a place to enter and keep track of my personal health information (medications, conditions, blood pressure, exercise, mood, sleep, etc)	3	0
….early warning that values are trending toward too low or high or you're on the way to needing something	3	0
….automatically record and save the information I text to and from healthcare providers	3	0
….easy access to my medical record	2	0

Feature	Number who Indicated Wanting the Feature	Number who Indicated Not Wanting the Feature
….a way to communicate with my doctor or healthcare professional	2	0
….see a record of my information over time, show trends and history	2	0
….constantly learning, changes with needs and preferences	2	1
….symptom management information	1	0
….warnings on values that are too low or high	1	0
….managing my appointments	2	2
….ability to text information or questions to a healthcare provider	1	1
….voice input to avoid having to enter information	1	1
….something that improves communication *between* my physicians about my health or medications	0	0
….getting feedback on information entered	0	0
….information on nutritional and ingredient information	0	0
….information about my medication	0	1
….help with setting up and achieving goals	0	1
….reminders to take medications	1	2
….instant response to questions (e.g. “should I eat this?” or “what interacts with this?”)	1	2
….managing medications (keeping track, ordering, interactions)	0	2
….a way to communicate with a health coach	0	2
….notifications when it is time to do things (check-ups, shots, etc.)	0	2
….information on new health products	0	4
….exercise motivation	0	4
….report of comparisons with other people with similar conditions	0	4
….information on relaxation techniques	0	5
….ways to interact with other people having similar interests and issues	0	5

Usability Sessions and Brief Field Test

For the prototype usability tests, across all task load measures the median rating was ‘6’ which is considered low demand (low demand 1-7, medium demand 8-14, high demand 15-21)(Table 4). Mental demand ratings were slightly higher on average than were scores on the other rating scales. The health assessment was the task set with the lowest (easiest) mental demand ratings and login, enrollment, and explore were associated with higher mental demand. The most taxing task set was the ‘explore’ task set. For this, users were left entirely free to independently explore the app. Although many navigation improvements were made after the earlier prototype session (see above), several remaining opportunities to improve navigation cues were identified from observing users as they explored this second prototype. These were converted to development priorities, implemented, and tested prior to launching the trial.

Table 4. Median score for task load scales (range 1-21) and five task sets. Seven users provided ratings.

Task Set	How mentally demanding was the task? (very low to very high)	How physically demanding was the task? (very low to very high)	How hurried or rushed was the pace of the task? (very low to very high)	How successful were you in accomplishing what you were asked to do? (perfect/failure)	How hard did you have to work to accomplish your level of performance? (very low to very high)	How insecure, discouraged, irritated, stressed, and annoyed were you? (very low to very high)
Login	10	8	2	6	8	5
Register	8	4	6	6	6	5
Enroll	11	3	4	4	6	5
Health Assessment	5	3.5	4	4.5	7	5.5
Explore	11	7	10	9	11	11

Results of the Iowa PHR Pharmacist Connection Study

A total of 80 participants enrolled (40 per group) and were randomized. Subsequently, three participants withdrew, one in the native+web app and two in the web-only group. The study group participants were balanced on all measured covariates (all p's >0.2) (Table 5). All but five of the 80 participants (two native+web app, three web app) interacted with the system (i.e. sent messages to the pharmacist, completed a health assessment, and/or entered health data). Two study pharmacists provided the intervention. Each patient had a unique pharmacist assigned to their case. Pharmacists were randomly assigned to participants within constraints of availability (e.g. when a pharmacist was on vacation, the other pharmacist would be assigned any patients who enrolled during that time). Pharmacist 1 was assigned to 39 participants (18 in the native+web app group, 21 in the web app group) and pharmacist 2 was assigned to 41 participants (22 in the native+web app group, 19 in the web app group).

Table 5. Baseline Description of Study Participants

Characteristic	Study Group	
	Native+Web App (n=40), Mean (±SD) or n (%)	**Web App (n=40), Mean (±SD) or n (%)**
Age	62.4 (5.5)	63.6 (6.6)
Female	24 (60.0)	24 (60.0)
White	35 (92.1)	38 (97.4)
Live Alone	17 (42.5)	13 (34.2)
More than High School Education	23 (69.7)	33 (82.5)
Medicare	14 (35.0)	13 (32.5)
Health Literacy (max=15, 3 items, 1-4 Likert scale)	14.6 (1.1)	14.6 (1.1)
Systolic BP, mm Hg	126.9 (13.1)	125.3(12.9)
Diastolic BP, mm Hg	76.4 (8.8)	73.6 (7.8)
Total Cholesterol, mg/dL	202.0 (43.1)	205.3 (61.6)
HDL, mg/dL	58.2 (16.5)	55.8 (15.3)
LDL, mg/dL	111.7 (34.5)	115.4 (51.5)
HbA1c (%)	6.5 (2.0)	6.3 (1.5)
BMI, kg/m2	31.4 (8.4)	31.8 (6.3)
Number of Medications	4.8 (3.4)	4.6 (4.1)
Number of Chronic Conditions	1.9 (1.3)	1.9 (1.5)
Hypertension	27 (67.5%)	25 (62.5%)
Diabetes mellitus	9 (22.5%)	11 (27.5%)
Current Smoker	5 (12.5)	4 (10.0)
Number of Guideline Advantage Metrics Considered	5.9 (1.8)	5.8 (1.9)

BMI indicates body mass index; BP, blood pressure; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; and LDL, low-density lipoprotein.

Primary Endpoints

The mean (SD) number of unique days of system interaction was 9.7 (7.6) in the native+web app group and 8.8 (8.6) in the web-only group (p=0.62). Corresponding median (range) number of unique days of system interaction was 8.5 (0, 33) and 6.5 (1, 48), respectively (P=0.41).

Across both study groups, a total of 1141 messages were sent, 449 by patients and the rest by pharmacists. Participants in the native+web app study group contacted the study pharmacists on a mean (SD) of 4.8 (4.9) days compared with 3.1 (3.0) days in the web-only group (p=0.06). Corresponding median (range) number of days pharmacists were messaged was 3.5 (0, 23) and 3.0 (0, 13), respectively (p=0.11). The mean (SD) number of messages to pharmacists was 6.2 (7.0) and 5.1 (6.1) (p=0.45) in the native+web app group and web-only group, respectively.

Secondary Endpoint

There were no significant differences between study groups in frequency of actionable GA metrics or pharmacist actions (Table 6). The system generated 465 requests for pharmacists to assess GA metrics for an average of 5.8 per patient. Of the system-generated metric notifications, 195 (41.9% of total) notifications for 60 patients were actionable and pharmacists made recommendations for 77 of the actionable notifications. The most common reason that a metric was not actionable was that it was found by the pharmacist to already have been met at baseline. Other reasons (in order of frequency) were that after review of further information they were not applicable to the patient (e.g. smoking cessation metric for a never smoker) or that their relevance could not be assessed due to insufficient information. There were a total of 92 pharmacist recommendations to either patients or providers (Table 6). When pharmacists were able to complete their action plan, they made recommendations to patients or providers the majority of time. There were more recommendations to patients than to providers. Recommendations to providers included to change, discontinue, initiate, or change the dose of a medication (n=19 recommendations), conduct a lab test (n=2), recommend vaccination (n=4), or recommend colorectal cancer screening (n=1). Providers indicated acceptance of all 26 recommendations (12 for native+web app group, 14 for web app group). The most common recommendations to patients were for lifestyle modifications such as weight loss and exercise (n=44), change in medication or dose (n=11), vaccination (n=6), further laboratory monitoring (n=5), blood pressure monitoring (n=3), and tobacco cessation (n=3).

Table 6. GA metrics assessed by study pharmacists and recommendations made.

Characteristic	Study Group		
	Native+Web App n(%) or Mean(SD)	Web App n(%) or Mean(SD)	p-value*
Total number of GA metrics considered	234	231	-
Total number of actionable GA metrics	99	96	-
Total number of actionable GA metrics with '*complete*' status	45	44	-
Total number of actionable GA metrics with recommendation made to patient or provider (% of actionable)	37 (37.4)	41 (42.7)	0.45
Total number of *complete* metrics with recommendation made (% of complete)	36 (80.0)	41 (93.2)	0.07
Total number of actionable GA metrics with recommendation to patient (% of actionable)	37 (37.4)	40 (41.7)	0.54
Total number of actionable GA metrics with recommendation to provider (% of actionable)	7 (7.1)	8 (8.3)	0.74
Mean number of GA metrics considered per participant	5.9 (1.8)	5.8 (1.9)	0.86
Mean number of actionable GA metrics per participant (SD)	2.6 (2.3)	2.5 (2.4)	0.88
Mean number of recommendations per actionable GA metric (SD)	0.5 (0.6)	0.6 (0.6	0.68
Mean number of recommendations to patient (SD)	0.5 (0.5)	0.5 (0.5)	0.55
Mean number of recommendations to provider (SD)	0.1 (0.2)	0.1 (0.2)	0.82

Exploratory Analyses

To further describe system uptake in each group we assessed the use of major features of the app, duration of app use, and percent who stopped interacting early (Table 7). There was a high rate of messaging pharmacists, completing the health assessment and entering medications in the app. Those in the native+web app group tended to use the app over a longer time interval, though the difference was not statistically significant. There were some differences between groups in how participants used the system. Those in the native+web app were more likely to enter medications and height and less likely to enter blood pressure or view reports on the study website.

Table 7. Description of system uptake including major features of the app and duration of use.

Characteristic	Study Group		
	Native+Web App n(%) or Mean(SD)	Web App n(%) or Mean(SD)	p-value*
Messaged pharmacist	34 (85.0)	31 (77.5)	0.39
Completed health assessment	34 (85.0)	37 (92.5)	0.48
Entered any health data	33 (82.5)	26 (65.0)	0.07
Entered medications	30 (75.0)	17 (52.5)	0.003
Entered health conditions	6 (15.0)	1 (2.5)	0.11
Entered blood pressure	9 (22.5)	20 (50.0)	0.02
Entered height	12 (30.0)	3 (7.5)	0.02
Entered weight	11 (27.5)	10 (25.0)	0.80
Viewed recommendations from health assessment	18 (45.0)	18 (45.0)	.
Viewed reports from study website (current medications, health assessment responses, wallet card)	6 (15.0)	14 (35.0)	0.04
Stopped interacting before 60 days	17 (42.5)	21 (52.5)	0.37
Mean date span interacted (first login to last activity date, days)	63.8 (36.3)	55.2 (38.3)	0.31

*Chi-square test or, if cell count less than t, Fisher's exact test

Discussion and Conclusions

As a result of our participatory design and usability testing, we learned that patients with cardiovascular disease are interested in keeping track of their health and medication information and are able to do so when a system is designed with their needs in mind. Working intensively with a small group of patients provided valuable insights on the design of a native mobile app targeted to them that would have been very difficult to obtain otherwise. We have developed a mobile app-enabled centralized pharmacist CVRS based on the lessons learned in the design sessions. Our app follows a minimalist approach, tracking as little information as possible while enabling meaningful use in order to increase adoption. An in-app health assessment generates specific recommended actions that patients can take and our pharmacist messaging feature supports in-app conversations with a study pharmacist. In a randomized controlled trial of smartphone users comparing the new native app with the app as accessed on the full website, sustained, repeated use was the norm and native app users tended to message more.

In intention-to-treat comparisons of the primary study endpoints, there was no significant difference in system engagement (a mean of 9.7 vs 8.8 days of system interaction, p=0.62; median 8.5 vs. 6.5, p=0.41) and a mean of 4.8 vs. 3.1 (p=0.06) days of messaging pharmacists (median 3.5 vs. 3.0, p=0.11) for native+web app vs web app only users. These mean differences (1-2 days) were smaller than the trial was designed to detect (5 to 10 days). On planned exploratory analyses, the native app users were more likely to enter medications (p=0.003), and web app users were more likely to enter blood pressure and view reports (p's=0.02). A total of 465 guideline metric alerts were considered by pharmacists and resulted in 92 recommendations communicated to patients or clinicians. A potential explanation for the minimal differences between groups is that both groups had access to the study pharmacists and the same core app functionality: the differences between the native and web app accessed via mobile device were largely look and feel of the user interface. It is unknown whether adding native app functionality such as ability to scan medication or food labels or locational services could have introduced more differences in system interactions. These features were not a high priority for users when ranked.

Participants remained engaged with the intervention. With a median (range) of 8.5 (0, 33) and 6.5 (1, 48) days of interaction and the majority of patients remaining engaged during the intervention period, these results are encouraging. This compares favorably with two trials[32,33] of web-based personal health records

which found low rates (16% and 49%) of return use. High drop-out rates in internet trials of self-help applications are beginning to be recognized as a 'natural and typical feature'[34] and absence of feedback from experts[35] may be in part to blame. Apps that include individualized feedback are associated with better health outcomes[36,37] and the tailored messaging with a study pharmacist may be one reason for our low attrition and sustained engagement rates.

The mobile-enabled centralized pharmacy intervention represented a novel practice model. Results confirm that it was able to be delivered, and we learned that pharmacists and patients wanted more rapid turnaround on messaging to support scheduled chat times. We were able to add this to the app soon after the first patients were enrolled. Study pharmacists based their interventions on the care they were delivering in the ICARE (*I*mproved *Ca*rdiovascular *R*isk Reduction to *E*nhance Rural Primary Care) study[17] and adapted this for total in-app delivery. In the ICARE study, there were more clinician and patient recommendations observed than in our Iowa PHR Pharmacist Connection Study. The ICARE study had a longer duration (12 rather than 4 months) to build the patient-pharmacist relationship and work on identified problems. In the ICARE trial, patient interaction was primarily by telephone and few (25%) ever logged in to use the web app which was available for their use but not reinforced by the pharmacists. Only 5% of ICARE intervention patients used the app to message the pharmacist. In contrast, a main activity of the study pharmacists in the Iowa PHR Pharmacist Connection Study was to frequently reach out to and interact with patients through the app.

This was a pragmatic design consistent with clinical practice: after a mailed invitation co-signed by their physician and the study PI, patients autonomously downloaded the app to their mobile device and began using it. Compared with participants in the ICARE study,[17] which used the same inclusion and exclusion criteria but enrolled patients in-person and conducted telephone calls with patients to deliver the pharmacy intervention, our participants were comparable in age, race and gender but had higher education (77% with more than high school education vs. 38%), lower BMI (32 vs. 38 kg/m2), were less likely to be a current smoker (11 vs. 25%), were taking fewer medications (mean of 4.7 vs. 5.7 medications), and had a lower prevalence of hypertension (65% vs. 89%) and diabetes (25% vs. 81%). Some of these differences may be attributable to our procedure for assessing study inclusion and exclusion criteria (we used structured data from electronic health records compared with in-person in the ICARE study). However some differences may be attributable to characteristics of smartphone app users. In our usability sessions we found that patients had few difficulties installing the app, however more favorable health behaviors, higher education and high health literacy of the mobile device users in our trial compared with the ICARE study suggests that individuals with lower e-Health literacy might need support to initiate engagement in the mobile app-enabled practice model.

We expected to confirm our earlier results[38] from design sessions with older adults to develop the original PHR website to manage medications safely. We confirmed:

- Patients want to keep track of a lot of information but are willing to enter very little, suggesting devices do the monitoring for them.
- Patients value and can design interactive feedback features, sketching communication features with providers, designing the look of the messaging interface to resemble a smartphone text conversation, and a menu or tabs to select what you want to do.
- Patients perceived privacy and security would be crucial for adoption, but patients were concerned that having to remember log-in and password information could affect use.
- Patients recommended some type of instructions on first use. In previous focus groups we noticed that being able to see a very quick video demonstration of how to use the system made it significantly easier for older adults to navigate and use the PHR.

We expected that patients would express positive attitudes and engage with the app that they helped design. Consistent with this expectation were the low perceived workload scores when working with the app and the proportion who logged-on repeatedly and manipulated health data multiple times substantially exceeded that observed in the original trial.[32]

An unexpected, new finding was that our patient design partners were very interested in an early warning feature that would alert them if health data were out of range, allow them to alert their health provider of out of range values, and frequent mentions of alerting first responders in dire cases. Examples frequently concerned diabetic blood sugars and possible loss of consciousness and may have reflected the prevalence of diabetes among the patients who participated. Although design partners were interested in early warning features, these were determined by the investigators to be inconsistent with the study objective of increasing adherence to cardiovascular risk reduction guidelines. Interoperability of monitored personal health data with lifeline systems is a potentially fruitful area for future development.

The purpose of this funding opportunity, “Disseminating and Implementing Evidence from Patient-Centered Outcomes Research in Clinical Practice Using Mobile Health Technology” was to develop and evaluate the effectiveness of novel approaches that use mHealth tools to enable the timely incorporation and appropriate use of patient-centered outcomes research (PCOR) evidence in clinical practice. We were able to demonstrate how a novel mobile app-enabled centralized pharmacist managed cardiovascular risk service can engage patients in risk reduction discussions and potentially stimulate greater adherence to evidence-based guidelines. These results support the long-term goal of the R21 funding opportunity which is to “foster the introduction of novel scientific ideas, model systems, tools, and technologies that have the potential to substantially advance research on the effective dissemination and implementation of PCOR findings into clinical practice.”

List of Publications and Products

Iowa PHR Pharmacist Connection Study: Supplemental Materials. Health Effectiveness Research Center (HERCe); Department of Epidemiology, College of Public Health, The University of Iowa; June 2018. Available at https://www.public-health.uiowa.edu/herce/research/iowaphr/index.html .

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