

Patients' experiences using a consumer mobile health application for heart failure self-management

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Abstract

Background: To support heart failure (HF) self-management, a team of hospital clinicians, patients and family caregivers have co-designed the consumer mobile health application (app), Care4myHeart.

Objective: This research aimed to uncover patient experiences using the app for HF self-management.

Methods: Patients with HF used the app for 14 days on their own smart device in the home setting, followed by a mixed-methods evaluation. Eight patients were recruited and six completed the Mobile Application Rating Scale and attended an interview.

Results: The overall app quality score was 'acceptable' at 3.53 out of 5, scoring highest in the aesthetics (3.83) and information (3.78) sub-scale. The lowest mean score was in the app-specific subscale representing the perceived impact on health behaviour change (2.53). The weight and fluid restriction sections were most frequently used with graphical representation of patient data an opportunity for improved self-awareness and ongoing learning. There was potential benefit to HF self-management as i) a communication tool for doctors to assist with care planning as all medical information is in one place, and ii) for daily management of illness with the benefits of accurately recording and reviewing personal health data. Participants however, were unsure this would fit into the way they conduct self-management as using the app for HF would require a fundamental change in daily routines. Technical problems with functionality and data entry issues were reported alongside relatively minor improvement suggestions.

Conclusions: The findings from this usability study suggest that a significant barrier to adoption is the lack of integration of technology into every-day life in the context of already established disease self-management routines. Future studies should explore the barriers to adoption and sustainability of consumer mobile health interventions for chronic conditions, particularly whether introducing such apps is more beneficial at the commencement of a self-management regimen.

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Original Manuscript

Patients' experiences using a consumer mobile health application for heart failure self-management

Abstract

Background: To support heart failure (HF) self-management, a team of hospital clinicians, patients and family caregivers have co-designed the consumer mobile health application (app), *Care4myHeart*.

Objective: This research aimed to uncover patient experiences using the app for HF self-management.

Methods: Patients with HF used the app for 14 days on their own smart device in the home setting, followed by a mixed-methods evaluation. Eight patients were recruited and six completed the Mobile Application Rating Scale and attended an interview.

Results: The overall app quality score was 'acceptable' at 3.53 out of 5, scoring highest in the aesthetics (3.83) and information (3.78) sub-scale. The lowest mean score was in the app-specific subscale representing the perceived impact on health behaviour change (2.53). Frequently used features were weight and fluid restriction tracking with graphical representation of data particularly beneficial for improved self-awareness and ongoing learning. Using technology for self-management would fundamentally differ to current practices and require a change in daily routines. However, use of the app was correlated with potential utility i) for daily management of illness with the benefits of accurately recording and reviewing personal health data, and ii) as a communication tool for doctors to assist with care planning as all medical information is in one place. Technical considerations included participants' attitudes to technology, functionality and data entry issues and relatively minor suggested changes.

Conclusion: The findings from this usability study suggest that a significant barrier to adoption is the lack of integration of technology into every-day life in the context of already established disease self-management routines. Future studies should explore the barriers to adoption and sustainability of consumer mHealth interventions for chronic conditions, particularly whether introducing such apps is more beneficial at the commencement of a self-management regimen.

Introduction

Heart failure (HF) affects at least 26 million people worldwide [1] including more than 1 million Australians [2] and it is expected to rise in prevalence [1]. The complex, highly-symptomatic syndrome is associated with high healthcare costs, high readmission rates and poor clinical outcomes [3]. Targets to improve functional outcomes, psychosocial outcomes, burden of care and survival of HF patients have resulted in a call for safe, person-centred, evidence-based action [3]. It is especially necessary to ensure equity of care for all patients through the efficient use of resources, as well as support to empower patients and caregivers in long-term care [4].

Self-management support - specifically around the non-pharmacological requirements - is critical to the effective management of HF [2], and is often delivered through educational measures (see for example National Heart Foundation of Australia [3, 5, 6]). Appropriate HF self-management involves daily weight monitoring, fluid restriction, dietary modifications and exercise alongside regular monitoring and follow-up [2]. In the home setting, recording and recognising changes such as increased weight, fluid retention and worsening symptoms (which are indicative of worsening HF), can allow patients to get help early [6]. However, challenges with translating guidelines into practice put patients at risk of sub-optimal care [2] with the complexity of HF self-management contributing

to poor adherence [7].

Rapid improvements in computing capability paired with the popularity of mobile phones in our communities provides more opportunities in healthcare delivery [7]. Due to this potential, mobile health (mHealth) interventions for HF continue to expand, however, this is not without challenges in technology adoption. Reliability of equipment [8], limited technical support [8], cognitive impairment [9] and variable interest in self-recording of health measurements [9] are a few of the factors affecting use in this patient population. Older people – with a HF prevalence three-times greater than the general population [10] - have variable levels of willingness to adopt technology [9]. They may lack confidence in their HF knowledge and rely on informal and formal caregivers for guidance [9]. Perceived usefulness and ease of use are considered the most important factors for mHealth adoption [11]. This poses specific challenges when designing interventions aimed to engage patients in HF self-management and highlights the importance of utilising patient perceptions in newly developed interventions. Further, of 34 consumer apps targeting HF on the commercial app stores included in a recent review, only three were evaluated in peer-reviewed articles [12], signalling the importance of disseminating research findings to advance consumer mHealth.

This study sits within a larger research program where *Care4myHeart*, a mHealth application (app) for HF self-management was developed in our hospital by a team of clinicians, patients and family caregivers. The diverse group of stakeholders collaborated to design an app which was relevant and useful to target users, and consistent with the evidence-based HF guidelines. The aim of this paper is to explore patients' experiences and feedback after using the app.

Specific research questions were:

1. What were the patients' experiences of using the *Care4myHeart* app; and
2. What is the perceived impact of the app on HF self-management?

Methods

A 14-day usability study using a mixed-methods evaluation was employed to uncover patient experiences using the mHealth app for HF self-management.

Participants

Self-selecting participants were recruited from cardiac in-patient units at a metropolitan private hospital in [blind for peer review] via posters and flyers located in common patient areas. Medical and nursing staff were informed of the research and referred patients who voiced their interest to participate. The inclusion criteria were English-speaking individuals with HF not highly dependent on medical care who reside at home, were able to provide feedback and owned a smart device capable of housing the application. Participants were excluded if they were involved in the co-design of the application, were cognitively impaired or otherwise unable to use the app. We aimed for a sample size of 8-10 participants because up to 80% of usability problems can be identified by this number of users [13].

Intervention

Details of the co-design process of the mHealth application are reported elsewhere [14-17]. The final design of the self-management app has three main components; *home screen*, *My Plan*, and *health management* sections. The *home screen* provides a shortcut to the priority *My Plan* icons based on patient goals, and a reminder summary. The *My Plan* section includes nine important components of heart failure self-management; medications, symptoms, exercise, weight, fluid, wellbeing, diet, blood pressure and pulse and future plans. A *health management* section contains a medical documentation repository, appointment calendar and healthcare professional contact details. The app provides the opportunity to collect, track and evaluate patient-entered data. Reminders, alerts, infographics,

videos, health professional advice and information pages throughout the app aim to guide patients to manage their HF. Sample user interfaces demonstrating the home, weight and fluid restriction screens are presented in figures 1, 2 and 3 respectively.

Figure 1: Sample home screen

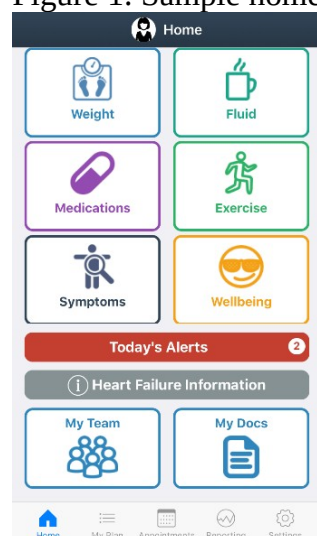


Figure 2: Sample weight screen

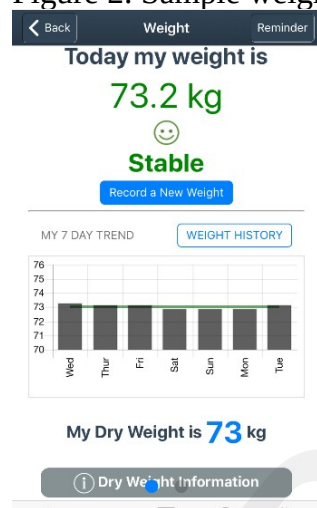
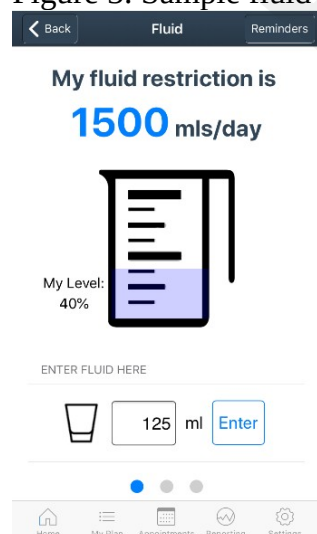


Figure 3: Sample fluid restriction screen



Study procedures

The *Care4myHeart* app was downloaded to patients' own iOS or android smartphone or tablet device after procedures were explained and patient consent obtained. A researcher spent 10-30 minutes providing an overview of the app interface, assisted with completing the personalised settings (dry weight, daily fluid restriction volume, daily step count aim, physical activity goals and reminders) and determined self-management priorities based on patient preferences. Participants were asked to use the app as frequently as required to assess its usability, aiming for at least daily use over a two-week period. Participants were encouraged to contact the research team by phone or email if they encountered problems or had questions throughout the study. For quality and safety reasons participants were instructed to continue with their regular care regime in collaboration with their healthcare providers. Ethical approval for this study was granted from [blind for peer review].

Data collection

As soon as practically manageable after the completion of a 14-day period, participants reported their user experience using both qualitative and quantitative methods.

Firstly, participants were asked to complete the Mobile Application Rating Scale (MARS) [18] either electronically (sent via email) or printed (sent by post or completed in person during the interview). The 23-item MARS is a multidimensional measure of the four objective app quality indicators; engagement, functionality, aesthetics and information (which together form the overall app quality score), in addition to a subjective quality subscale [18]. As *Care4myHeart* was not available on the app stores during the time of the study, we modified the MARS to 19-items, excluding four items because they were not applicable; accuracy of app description (item 13), goals (item 14), credibility (item 18) and evidence-base (item 19). These items were removed from the mean score calculation as per the guidelines [18]. A supplementary, modifiable 'app-specific' section assessed the perceived impact of the app on users' target health behaviours [18], in this case, improved heart failure self-management. MARS items are scored on a 5-point Likert scale (1=inadequate, 2=poor, 3=acceptable, 4=good, and 5=excellent) [18]. The version used for this study is attached [Multimedia Appendix 1: Modified Mobile Application Rating Scale].

Secondly, participants were asked to attend an interview on the hospital campus or via phone, depending on patient preference. A semi-structured interview schedule included such questions as i) *What worked well and what could be improved?* ii) *What functions did you use and why?*, and iii) *Would this application impact the way you look after your health?* Participants were given the opportunity to share experiences, communicate thoughts and voice perspectives through interviewer use of open-ended and probing questions. App use was self-reported by participants themselves as no usage data was collected in this study. Data were collected in June and July 2018.

Data analysis

Data were de-identified and treated confidentially. MARS data were managed in the database software program Excel with mean scores produced by calculation of participant subscale scores. Interviews were transcribed verbatim and thematically analysed using Braun & Clarke's process [19]. The process involved familiarisation of the data through re-reading transcripts (Step 1), generating initial codes and writing them directly on the transcript segments considered interesting or meaningful to the analyst (Step 2), organisation of codes into potential themes (Step 3), review of themes through checking and generating a thematic 'map' (Step 4), generation of clear definitions and names for each theme (Step 5) and production of the report with compelling examples through a final analysis (Step 6) [19]. Data analysis steps 1 and 2 was conducted by the lead author [author initials blind for peer review]. Steps 3 to 6 was done visually and collaboratively with the themes confirmed by group discussion with co-authors.

Results

Eight participants consented and commenced the usability study. All participants were male (n=8), most lived with a spouse/partner (n=7), were currently employed (n=5), and more than half resided in a rural location outside the metropolitan area (n=5). The average age of participants was 69 with a range of 61 to 84.

One participant discontinued with the study after reporting technical challenges with a software update which occurred during the 14-day period. Meanwhile, a second participant passed away prior to the final interview and collection of the MARS. Six of the eight participants completed the study with the survey and interview. Interview length ranged from 18-29 minutes.

MARS App Quality Scores

Table 1 presents the four subscale scores (engagement, functionality, aesthetics and information) which make up the overall quality score, as well as the subjective quality score (representing satisfaction) and app-specific score (representing behaviour change).

Table 1: MARS subscale means with standard deviations in parenthesis

Subscale ^a	Items	Mean (SD)
Engagement	Entertainment	3.33 (1.03)
	Interest	3.83 (0.75)
	Customisation	3.00 (0.89)
	Interactivity	3.00 (0.89)
	Target group	3.67 (0.82)
	Subscale mean	3.37 (0.69)
Functionality	Performance	2.67 (1.63)
	Ease of use	3.67 (0.52)
	Navigation	3.67 (1.03)
	Gestural design	3.33 (0.82)
	Subscale mean	3.33 (0.66)
Aesthetics	Layout	4.17 (0.75)
	Graphics	3.67 (1.03)
	Visual appeal	3.67 (0.82)
	Subscale mean	3.83 (0.81)
Information^b	Quality of information	3.80 (0.84)
	Quantity of information	3.60 (1.52)
	Visual information	4.17 (0.41)
	Subscale mean	3.78 (0.81)
Overall quality		3.53 (0.63)
Subjective Score	Recommendation	3.50 (1.22)
	Use in 12 months	4.67 (0.82)
	Pay for the app	1.67 (1.03)
	Star rating	3.33 (0.82)
	Subscale mean	3.29 (0.70)
App-specific	Awareness	3.17 (1.17)
	Knowledge	2.67 (0.52)
	Attitudes	2.33 (0.82)
	Intention to change	2.33 (0.82)
	Help seeking	2.33 (0.82)
	Behaviour change	2.33 (0.82)
	Subscale mean	2.53 (0.71)

^a MARS values range from 1 - inadequate to 5 - excellent.

^bThe information quality score excluded items 13, 14, 18 and 19 of the MARS.

The overall app quality score was 3.53 out of 5. Of the four subscales, the highest scores were aesthetics (3.83) and information (3.78), followed by engagement (3.37) and functionality (3.33); all above the minimum acceptability score of 3.0. The highest-scoring individual items were layout (4.17), visual information (4.17), interest (3.83) and quality of information (3.80). The lowest scores per item were performance (2.67), customisation (3.00) and interactivity (3.00).

The subjective quality subscale representing app satisfaction averaged 3.29 out of 5. Most participants would use the app in excess of 50 times in a 12-month period (n=7), recommend the app to people who might benefit from it (n=4), but would not pay for the app (n=4). The mean star rating - comparable to the star rating on the app stores - was 3.33.

The lowest mean score was in the app-specific section representing the perceived impact of using the app on health behaviour change (2.53). The app may have some impact on increased awareness regarding HF self-management (3.17) but was rated 'poor' on the perceived impact of the app on attitude, intention to change, help seeking and overall behaviour change (2.33).

Interview findings

Analysis of interview transcripts resulted in three themes and ten subthemes. See table 2.

Table 2: Summary of the themes and subthemes from participant interviews

Theme	Subthemes
App use	Weight, fluid restriction and step counter
	Use of features
	Graphs as visual representation of patient data
Capacity for self-management	Established HF understandings and practices
	App for daily management of illness
	App as communication tool
Technical considerations	Attitudes to technology
	Functionality
	Data entry
	Suggested changes

Theme 1: App use

Most participants used an android device (smartphone n=2, tablet n=2) and two used iPhones. Five participants had both a smartphone and a tablet device. Tablets were kept at home and smartphones were not necessarily used for internet access, yet those who carry their smartphone in their pocket saw the benefit in data entry throughout the day. iOS users spoke about using their device with greater understanding and confidence than Android users in our sample – they were also the two youngest participants. Self-reported app use averaged 5-10 minutes once or twice a day on most days during the usability study. The app was used independently without family member involvement. Usage over the 14-day period decreased once users determined what was useful however version updates improved technical issues with usage reportedly increasing after the updates.

Weight, fluid restriction and step counter

The weight and fluid restriction sections were most frequently used. The quick speed of recording weight and weight alerts was highlighted as positive features. One participant described how beneficial the fluid recorder was; ‘The most beneficial feature for me at this point in time is the fluid intake. . . . the fluid counter is excellent. I love it, absolutely love it.’ (Participant 8 [P8]). Fluid volumes were entered either throughout the day or at the end of the day in the fluid restriction section of the app as a participant described; ‘I wouldn’t put in fluid every time I had 100ml of fluid - I put it all in at the end of the day’ (P7).

Some found the app more convenient for fluid restriction self-management than traditional means of recording fluid volumes because it was portable:

Beforehand what I was doing I had a measuring cup. . . . I think the app is more friendly for me to use. . . . I’ve got that in my pocket, I can always - when I’m out and about - I can make an input on my smartphone and it’s just so convenient (P8).

To a lesser extent the step counter within the exercise section was used.

Use of features

Not all features of the app were used by participants. Participants did not regularly use the symptoms, documents, medication list and calendar sections, yet many saw potential advantages in using these additional features stating, ‘I didn’t use everything but I can see other people could find it very useful’ (P1). For example, due to the frequency of medication changes common in patients with HF, keeping an updated medication list was perceived a positive feature. Participants did not use these features during the usability study stating they ‘didn’t really get a chance to go through it’ (P6), and ‘ah, I had a look but I didn’t use any of it functionally’ (P7).

Reasons participants did not watch the instructional exercises videos were disinterest, personal

preference to undertake their own form of exercise and awareness they wouldn't continue after a few weeks watching the same videos. Additional reasons for not using all the features of the app included technical issues and a lack of perceived value for the time required for data entry. One participant commented on why he hasn't taken the time to enter his medications and doctors contact details into the app:

I'm just trying to wait until I get my medications stabilised before I make the inputs. . . . My doctor's names and all of that information I haven't put that in yet but I will over time. It's just – ah – I've I tell you I've been so busy since getting back [home after hospital], just busy busy and relaxing after 4 weeks in the hospital (P8).

HF information was considered useful for a few patients however most participants felt the information was already known to them saying 'there's no new material for me actually' (P6). Another participant explained how the lack of new information relates to perceived utility of the app:

For me it's things I already know, . . . I know I'm big on diet, big on health, so a lot of this information in the app I already know but it just reinforces it, . . . I do enjoy the app but I don't need it (P8).

Graphs as visual representation of patient data

Visual representation of patient data through graphs was a positive feature of the app, specifically for self-awareness. For daily weight management, graphs were deemed useful, accurate, relevant and provided feedback to users as viewing 7-day weight trends heightened self-awareness. A participant explained how the weight trend allowed him to be more 'weight aware' (P2) and another appreciated the visual representation of health data specifically and said:

In a graphical sense you see [the weight trend] straight away. And your brain functions on that rather than on just a list of numbers (P7).

Self-awareness regarding mobility was deemed beneficial in the exercise section as well. The 7-day step counter graph provided an accurate picture of patients' own mobility status for those who used the feature as one participant commented; 'I'm just trying to keep track of how much activity I'm doing, to make sure I'm . . . keeping moving' (P1).

Graphical representation of patient data provided learning opportunities. Monitoring the link between fluid intake and fluid congestion can be challenging yet graphing this data may assist, firstly to review previous day's fluid intake and secondly, cross reference this information with fluid congestion symptoms which may be caused by previous days' non-adherence, as one participant explained:

[It] appears in your record that you can go back and look and then gives you some sort of positive understanding about what you might have done wrong. . . . your ankles swell up the following morning and you think "ahhhh dopey bugger, I should have bloody been more careful" so and they're lessons we all learn, . . . recognising [I've] gone over [my fluid restriction] (P7).

Theme 2: Capacity for self-management

Participants were unsure how *Care4myHeart* would fit into the way they currently understand HF and conduct self-management as using the app for HF would require a fundamental change in routine. However, there was potential benefit to HF self-management i) for daily management of illness with the benefits of accurately recording and reviewing personal health data, and ii) as a communication tool for doctors to assist with care planning as all medical information is in one place. These three sub-themes are discussed below.

Established HF understandings and self-management practices

Participants found their own way to self-manage their health. Living with the condition for many years, understanding the importance of self-management and setting goals regarding self-

management had contributed to their existing behaviours embedded into daily life. Existing self-management strategies were many; measuring jug on kitchen bench for fluid intake monitoring, digital calendars, shared household calendar on the back of the pantry door for medical appointments/reminders, liaising with specialist nurses via email and paper files containing medical documentation.

Participants reported satisfaction with their current healthcare. Notably, patients reported easy access to healthcare professionals for regular follow-up, ongoing education/information and question answering. Participants spoke highly of their current general practitioner, cardiologist and HF nurses, for example one participant commented; 'I've got the heart nurse's phone number and mobile number too. She's absolutely fantastic' (P3). Participants were aware of and follow a self-management care plan in conjunction with their healthcare team, knowing their condition is life-limiting. The satisfaction with these current routines was demonstrated, as one participant explained in the following quote:

I mean why do I need an app to tell me that ah "do this, do this and this, and you're going to have a better life"? Whereas I get all of this so-called experts, the doctors and all of the information they give you, they tell you the same thing [as the app]. . . . I don't necessarily need an app. Personally, I'm going to do the right thing because I want to live. . . . I know I'm dying. I'm dying as we speak, there's no secrets here but I want to live so I'm going to do the right things. (P8).

Existing self-management strategies were in a different location or different format to the app. Participants compared the convenience of their existing strategies to using the app for self-management. Particularly, participants critiqued the need to 'go to various pages on the program' (P3) to view health data whereas participants commonly documented in a notebook or electronic spreadsheet. These existing records have been tailored to the specific requirements considered important by the patient themselves or their healthcare team. The benefit of these existing daily records was the ability to view their health status at a glance and as a self-management checklist, as one participant explained:

I can just look at one page and get the whole picture of what's happening . . . it's all on one page, so I can tick something when I've taken it . . . I just have a look at [the page] and see that I've done everything that day and basically, . . . well that's the day done, I'm complete (P3).

Further, existing strategies were considered easy and time efficient in everyday life as one participant explained about maintaining his fluid restriction throughout the day compared with using the app:

I would personally keep going the way I'm going cos of the ease of doing it. . . . [T]he easy things I'd rather just do easy, like the water in the jug, . . . where the app's stuck in my bedroom most of the time. I've gotta go and turn it on, I've gotta go bang, bang, bang, and by the time I've sorta done the water in the jug I've well and truly finished before probably I've even get into the program properly (P3).

While the app may assist in monitoring specific self-management activities like weight or fluid intake, the app did not seem to embody the complexity of HF self-management. Participants communicated a good understanding of HF (with the exception of one participant who wasn't familiar with the term 'dry weight'). They correctly understood fluid congestion was variable, that fluid intake and diuretic medications are directly linked to fluid status and regular self-assessment for abdominal/ankle oedema was necessary. These HF understandings involved a more thorough and subjective self-assessment, not directly equivalent to the setting's parameters within the current design of the app. The following quote explains the thought process of a participant while conducting a self-assessment which was a more complex process than simply adhering to a daily fluid restriction:

Sometimes I will go over my fluid intake which is 1.2 [litres], sometimes I go over because I'm looking at the way I feel. . . . I'm doing a couple of things. I'm looking at the fluid intake

but I'm also looking at my body or seeing the way I feel. . . . I'm looking at how dry I am. . . . I'll just drink a little bit more and not get a doctor review [because] I haven't started to pick up any signs of oedema (P8).

App for daily management of illness

The app provided a routine to manage health data like weight. Participants explained that 'it generates a discipline to maintain the information' (P2) specifically regarding 'the daily management of my fluid balance, it takes a lot of adjustment . . . to get the balance right' (P1). Entering weight was quicker using the app than usual format of documenting weight for some proclaiming 'this is a quicker way of doing it, like most computers it can store information well' (P2).

Recording health information within the app on a daily basis was considered more accurate than manual measures or memory. One participant explained how he normally relies on memory:

I don't record it as such but I check it every couple of days keeping a mental note – I just want to make sure there are no big variations from day to day so that's all I look for [but with the app] it's nice to have that trend, I like it, it gives you a more accurate picture (P6).

The health data repository and feedback within the app provided an opportunity to view a person's health status more objectively. For example, accurate recording of health data might help family members care seek appropriately during times of worsening HF as a participant explained:

If you go into denial stage and don't pay attention to the weight because you don't want to go into hospital or something, now they can look and see "Ah well that's not right – we should get you to the doctor" so I think it would help (P1).

App as communication tool

The app was considered a potential tool to communicate to doctors and other health professionals to assist with care planning. Participants explained how the app could facilitate accurate information sharing:

[The app] enables you to communicate with your medical practitioner in a fairly accurate - one would hope - way, about what's been going on and therefore one would hope, if you were the medical practitioner, I suppose it would cause the medical practitioner a better basis of making decisions about your medical care (P2).

As a potential communication tool, the app could assist doctors with patient assessment. Participants frequently spoke of the potential to show doctors the graphs representing health-related trends of recent days either in a consultation stating 'it's quick' (P7) or over the phone suggesting; 'If you had it on a phone you could just say [to the doctor] "Look, I'll send this through to you"' (P7). Another participant agreed with this potential:

The concept is good because you can take your tablet along to your doctor and he says "well how have you been?" and you can say "well there you are, there's my weight, there's my blood pressure", so you've got that information available (P2).

Having medical information in one place was deemed useful if all relevant data was stored the app. Digital storage of personal medical records was considered 'very powerful and very useful' (P7) as participants saw benefit in having 'everything in one place' (P6) and 'recorded accurately' (P1). Digital copies of medical information were considered 'much easier rather than carrying an actual physical document. Sometimes I forget to take it' (P6). The potential to use the app as a communication tool was deemed especially valuable for new or temporary doctors and during medical emergencies:

Just air drop [my current medication list] from your phone to the doctor in casualty or whatever I think's a great, very good idea . . . I think that would be helpful for a lot of people especially if you come into hospital somewhere hypoxic, . . . unconscious or whatever, . . . or too breathless to talk about it. I've got a very very extensive list of drugs that I'm on, I think it's 35 tablets a day usually, so having that list when I've gotta provide it, makes it much

easier (P1).

No participants however, reported using the app with members in their healthcare team during the time of the study. Further, the version used for the usability study was not set up for third-party access.

Theme 3: Technical considerations

There were technical considerations influencing the experience of using the app, including attitudes to technology and functionality and data entry issues. These sub-themes are reported in the following section alongside the final sub-theme, reporting numerous suggested changes to improve the app's design.

Attitudes to technology

Predominantly, participants were not regular users of smart devices for apps or health. Three sample quotes demonstrated the minimal interest in using smart devices overall; 'I'm not a big user of phones, especially mobile phones' (P8), and 'I don't particularly like turning computers on anyhow, I mean I'd go a fortnight without reading my emails' (P3) and 'I'm a dinosaur and not used to using texting' (P7). Trust was a reason one participant won't use internet banking or purchase products using a credit card (P3). Participants reported using their smart devices for google calendar, checking the weather forecast, playing games (CandyCrush, solitaire, crosswords), internet searches and only a few use emails. In relation to technology use for health, one participant reported using a health app for HF self-management and another stored his current medication list in the notes section of his smartphone. No participants reported storing medical documents electronically.

Participants believed in the inevitable advancement of technology in the contemporary era and this was perceived to include the acceptance of health apps like *Care4myHeart* for younger generations. With the every-day use of smartphones, the younger generation 'would approach it completely differently' (P7). Another participant explained:

I think for really the next generation and computer nerds at the moment you're on a winner there, I really do. . . . As you get the younger ones come through you'll be fine, which will happen just over time (P3).

Attitudes to technology by family members appeared consistent with that of participants. There were no reports receiving assistance with using the app from family members as one participant explained; '[my wife is] less techno-cradic [sic] than I am. I mean she went from a phone with a touchscreen back to a phone with push buttons on it, that's what she likes' (P7). The personal nature of smartphones may impact the divide between family members; '[It is] my phone so she didn't really take a closer look' (P8).

Functionality

Technical challenges were reported affecting usage, more prevalent on Android than iOS. Issues downloading the version update on Android caused one participant to discontinue participation in the study. A second participant was unable to download the updated Android version but managed to continue with the original version downloaded at the beginning of the usability study saying:

The whole thing stands still. Still. Still doing nothing. . . . The process of downloading the app is pretty clearly signposted, I'm not complaining about that, it just didn't work (P2).

Technical issues with the Android version also included lengthy app loading, a blank 7-day weight graph and the inability to record blood pressure readings, set medication reminders and use the clock function. Virus protection interference due to the app being from an unknown source was also reported regardless of approval of unknown sources in the settings section of the device. The iOS version had less technical issue reports overall but a lengthier multi-step initial download process and intermittent screen freezes was noted.

Technical issues were a barrier for ongoing use. Participants commented on the ongoing struggles

with the usability saying, 'I've persevered with it . . . but I found I was battling [with the app]' (P7) and 'whether it's me or whether it's the program or a combination of both I don't know, but that's your problem' (P3). The potential benefit of the app versus the technical challenges associated with the app was reflected on:

I still think the idea is good and I think it's easy enough to use if it works but I've still got problems with the execution, you know (P2).

Interestingly, participants seldom reported technical challenges encountered to the research team during the usability study however raised these issues during the interview.

Data entry

Navigation and data entry were specifically problematic. Participants reported physical limitations during the operation of the app saying they have 'big clumsy fingers' and their 'hands shake a little bit' (P7). Participants experienced time consuming data entry in the medications section, challenges with using some buttons and confusion completing or updating the settings.

Strategies to overcome these limitations were evident as participants had insight into their own ailments:

Sometimes I lick the end of my fingers and that might be a factor of fluid, my fluids are very low and I'm quite dry (P7).

Awareness of these functional limitations was a factor in participants choosing a tablet device over a smartphone if they owned both saying, 'I've got fat fingers and the phone's got a small keyboard' (P2). Further, the consequences of incorrect data entry in the settings component of the app caused inappropriate alerts. One participant explained about an alert associated with incorrect entry of dry weight:

It told me horror stories about what I should do in terms of consulting my medical practitioners, when in fact I had simply a [settings] error on the machine (P2).

Suggested changes

Many suggested changes were provided in relation to data entry issues, utility by the HF population and to make it more appealing for the user.

Usability improvements regarding the data entry challenges experienced were many. Participants wanted more control over their data reporting, 'people are generally pretty honest about the way they deal with their own data' (P7). Participants wanted to clear previously entered or incorrect data, edit previously entered data and enter retrospective data, in the case it was missed causing incomplete weight graphs. A participant explained:

If you're out for the day say and you leave your phone at home and you come back and want to add the data the following day, you can't do it, so I think that is definitely a negative (P7).

Having an empty data entry screen without predicted or previous amounts was important to avoid confusion during data entries. This was noted for documenting fluid intake and in entering daily weight as explained by a participant:

It comes up with the last weight you put in so you have to delete that before you can actually [put] a revised weight in and I think that's a mistake. I think the window should be clear and you just enter in the data you want to enter (P7).

Secondly, there were suggestions to improve the applicability to the patient group. These included recording more health data, document medication variations more easily, add a medication checklist function, the ability to go over the maximum fluid restriction volume and add a free-text general notes page.

Making the user interface more appealing was deemed necessary for engagement with the app. Suggestions included visualisation of fluid overflowing out of the fluid jug or going red in colour and more graphical information with an increase to a 14-day trend. Participants explained their want for a more interesting interface through the example quotes; 'if you can have some whistles and bells and

things like that – it just makes it a little bit more interesting’ (P8) and ‘some screens are very average looking. . . . I think if you could brush it up a little bit and um, make it more appealing some of the screens . . . would be nice actually’ (P6). These improvement suggestions would perceptibly improve the utility of the app as one participant explained:

[To] make notes about day to day things. . . . just like a general notes page. That would be a great idea. . . . That would be the decider for me to use it over the other one [app] (P1).

Miscellaneous suggested changes included a simpler keyboard, ability to change to horizontal view on the tablet version and the logo on more screens.

Discussion

Learning from failure

This paper presented the findings from a usability study conducted with patients using a mHealth app for heart failure. We explored the way the app was used and the perceived impact on disease self-management. In this context, frequently used features were weight and fluid restriction tracking with graphical representation of data particularly beneficial. Using technology for self-management would fundamentally differ to current practices, however use of the app was correlated with potential utility for daily condition management and as a communication tool. The overall app quality score as assessed by the MARS, was slightly higher for *Care4myHeart* (3.53) than an average of the 34 comparable HF support apps on the consumer app stores (3.4) [12]. In its current form, the perceived impact on health behaviour change was classified as ‘poor’ in the MARS app-specific subscale. Patient experiences using various app components highlighted challenges and opportunities for design improvements for the next version of the *Care4myHeart* app. In addition, patient experiences have implications for researchers investigating digital health systems for chronic disease and consumer app designers wishing to incorporate human factors. Many lessons were learned from the usability study and are described below.

Lessons learned

The following lessons were learned from the evaluation of *Care4myHeart* by patient participants.

Lesson 1: Self-management is integrated into everyday life, so if technology is not, then that is a significant barrier to adoption

Integrating self-management with normal life patterns has been identified as a key enabler of effective self-care in HF [20], and participants in this study have well-established daily routines. Clarke et al. [20] described how HF patients enlist ‘cues’ in everyday life as routines to facilitate guideline adherence. For example, to integrate self-management activities with the morning routine patients may locate pill boxes on the breakfast table as a visual reminder for medication adherence [20]. Participants in the usability study for *Care4myHeart* reported various cues and, except for a few, reported their ease and desire to continue with existing routines. Demonstrating this, the use of a measuring jug on the kitchen bench for daily fluid restriction management served three functions; a visual reminder to limit oral fluids, functional measuring tool and an accurate, visual representation of cumulative fluid intake at any point in the day. This presents a more convenient option for participants who had their smart devices located elsewhere in the house and a more practical option given the inability of the technology to measure fluid volumes. Participant reflections in comparing the use of technology in HF were consistent with the recent study conducted with older people with HF by Nguyen et al. [9^{p139}] who found ‘some patients did not find technology to be useful or relevant in their daily activities because they were already comfortable with their routines’. Similar reasons likely contributed to the low perceived impact on health behaviour change reported in the MARS and indifference to explore all app features, as participants felt the app did not enhance existing self-management. Consequently, introducing the app at the commencement of a self-management

regimen may be more beneficial and needs further investigation.

The private nature of smart devices may be a barrier to adoption itself. In this study, no participants reported the involvement of family caregivers regarding the use of the *Care4myHeart* app. Yet historically, caregivers are frequently involved in HF [21] with some patients dependent on their caregivers to make health-related decisions [9]. The gradation of dependency of caregivers for older adults with chronic conditions [22] presents challenges in designing future support interventions [20] when daily health-related activities involves caregivers. The technology risks excluding caregivers unless the design supports their active involvement and the resultant design presents a perceived benefit to patient *and* caregiver.

Lesson 2: The biggest benefit is the opportunity for improved self-awareness and continuous learning in HF

The timely detection and recognition of and action to subtle changes in symptoms is noted as a key skill for effective HF self-management [20]. According to patient experiences, the self-management app we have developed offered possibilities for a more active role in daily recording and reviewing of HF-related data. Participants specifically saw benefit in the graphical representation of their data with the ability to view trends, detect changes representative of worsening HF and take action accordingly. Previous studies have shown the skills in HF evolve over time with learning from past experiences helpful in applying effective strategies to daily life [21]. This was particularly evident with patients' experiences using the 7-day weight trend feature. Participants felt it was accurate and timely, providing an objective representation of their health status to watch and/or act when needed. We argue that the use of mHealth via an app with real-time representation of data trends would strengthen patient empowerment and decision-making in self-management.

To realise the potential for improved self-awareness and continuous learning however, engagement improvements are needed. A recent review - which compared the quality of 34 HF support apps on the consumer app stores using the MARS - found the lowest subscale score was engagement at 2.9 out of 5.0 [12]. This led to a call for further improvements in engagement of mHealth apps for HF support. In the context of our study, *Care4myHeart* had an engagement subscale mean of 3.37 - higher than the average in the review - however, this score still falls short of the 'good' range. In this regard, participants conveyed valuable suggestions to improve the interactivity and customisation of the app, in addition to suggestions to make the interface more interesting and entertaining. Incorporating the many suggestions provided from (just) six participants in the study may greatly improve the interface for future users. The suggested changes are relatively minor to incorporate in iterations, as they have been in other usability studies [23] achieved through usability studies of similar sample sizes of 5-10 participants [24-26].

Lesson 3: Patients need a way to manage their health information across the healthcare system

The findings of this research indicate participants want effective ways to share their data with healthcare professionals for ongoing care. Participants perceived the app effective as a communication tool to share their data in a timely, accurate and visual manner so that healthcare professionals can be armed with all relevant health information - contained in one system, especially in an emergency or unfamiliar healthcare setting - for care planning. Currently, Australia is transitioning to an opt-out electronic health record however during the usability study period participants' health information was largely held in silos by individual health providers. Participants reported the safety and quality benefits to record, store and manage health information in one place, whether it be the *Care4myHeart* app or another assistive technology. These participant perspectives are mirrored in a recent study investigating experiences using the patient accessible electronic health record in use in Sweden [27]. Over 96% of survey responders had an overall positive perception of the system, reporting the highest-rated reasons why they felt it important to have access to their health-related information; (1) it makes them feel informed; (2) it improves communication between medical staff and them; (3) it improves the understanding of their condition; and (4) it makes them feel safe [27].

Condition-specific mHealth apps have limitations for integration to current health information systems across acute care, primary care and community care. Standalone apps will not reach their potential to aid self-management without integration across healthcare providers, because, like other chronic conditions, patients with HF have concurrent co-morbid conditions [1], experience frequent hospitalisations [3] and require a team approach across healthcare sectors [5]. There is increasing recognition that health services for those living with chronic conditions need to be more integrated, coordinated and patient-focused across the continuum of care [2], however mHealth has specific challenges in addition to other service re-design efforts. For example, health system readiness, organisational resistance to change, policy uncertainties and unclear reimbursement schedules for clinicians have been previously identified as barriers to the successful implementation of mHealth technologies for chronic conditions [22].

Lesson 4: Technical challenges are a significant barrier to use with most patients unlikely to persevere

Attitudes to technology use impacted on participant experiences using the app. The complex components within the app requiring more navigation and data entry – for example the medication list feature – were infrequently used. These complex components were more likely to have technical and functional issues which was an additional deterrent reported by participants with less confidence using technology. For the few participants who self-reported daily app use, the technical challenges were less of a hindrance but these participants were more likely to provide specific interface improvement suggestions.

The findings of this usability study have led to recommendations around technology use for usability studies conducted with patient participants, which may be particularly beneficial to clinician researchers. Firstly, testing and re-testing prior to allowing patients to use the technology is important to help mitigate frustration of poor functioning technology, a previously reported fear in older adults with HF [9]. Secondly, avoiding version updates during a usability trial will limit confusion, particularly when the researcher cannot screen share with patients located in rural areas to guide the process. Finally, considering recruiting patients who use apps daily as ‘early adopters’ of mHealth for HF because of the variable levels of technology acceptance in this patient population [9]. Our findings were consistent with Nguyen and colleagues [9] who found patients were keen to manage their HF and willing to uptake self-management recommendations, but discovered that for some patients adopting a new technology on top of their daily health routines may be of little benefit. Time and effort were barriers to technology acceptance [9], consistent with the findings from this study where the ease and convenience of continuing with existing self-care regimens outweighed the technical challenges of learning how to use a new app. This would also account for the seldom reporting of technical difficulties during the study. Participants likely made decisions about their acceptance of the app early in the study period therefore lacked motivation to troubleshoot technical issues with the research team. We found these barriers to technology use were regardless of the participant’s keen interest to participate in the research and optimism for technology to assist with their health, noting the demographic of study participants were older males only.

We tried to minimise technical challenges by using a participatory, co-design approach involving patients in each stage of the development, however this was not reflected in the study’s findings. This challenges the assumptions of the co-design methodology in addressing the needs of target users and improving usability and further emphasises the non-homogenous attitudes of patients with HF when considering technology and health.

Recommendations for future research

Future research should explore in what formats and contexts technology can positively complement daily self-management activities conducted by patients with HF. Importantly, we must incorporate the vital caregiver role in the design of condition-specific mHealth because of their active role in

self-management support in the home environment. A more focused understanding of the design considerations to engage users in an interesting and beneficial way are likely necessary for adoption and ongoing use, which will require the interdisciplinary collaboration between designers, developers, healthcare providers and healthcare consumers. Third party access to medical information in the app, especially in an emergency, may be an important design recommendation and should be investigated.

With the limited number of evidence-based mHealth interventions moving past the pilot or feasibility stage [22], future studies should investigate the many barriers to adoption and sustainability. Implementation science of mHealth applications for chronic condition self-management as an adjunct to existing care is an important area for further research, specifically investigating perspectives of clinicians, health system administrators and policy makers.

Limitations

Since data collection the authors are now aware of a user version of the MARS called uMARS [28], which would have suited this participant sample more specifically as healthcare consumers. A limitation of this research is the selection bias of the patients. First, as per the inclusion criteria all participants owned a smart device. Second, less adherent patients, for whom the application may be most beneficial, are often not willing to participate and may have reported different experiences to this sample. The findings from this study conducted with a small and homogenous sample, cannot be generalisable to the wider heart failure population but nevertheless provide insight for further research on the topic.

Conclusion

A mixed-methods evaluation of patient experiences using a mHealth app for HF showed how the app was used and perceived impact on self-management. Daily self-management habits are established without the use of technology so patients were unsure how the app would fit in their current routines. Nevertheless, participants saw the potential of the app to aid daily condition management, particularly regarding weight and fluid restriction management, and serve as a communication tool to healthcare professionals involved in their care.

Understanding users' experiences contributes to design improvements for the *Care4myHeart* app and the lessons learned have implications for researchers and development teams to advance the quality of consumer mHealth apps for chronic conditions. Future studies should investigate the barriers to adoption and sustainability of consumer mHealth interventions, including whether introducing such apps is more beneficial at the commencement of a self-management regimen. Research into how to incorporate the important caregiver role in the design of technology to support self-management in the home environment is also needed.

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Multimedia Appendix

Multimedia appendix 1: Modified Mobile Application Rating Scale

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