

# Patient Perspectives on Performance of a Smartphone App for Atrial Fibrillation Self-Management

Paul Mihas<sup>1</sup>, Lindsey Rosman<sup>2</sup>, Tiffany Armbruster<sup>2</sup>, Jennifer Walker<sup>2</sup>, Zack Deyo<sup>3,4</sup>, Anil Gehi<sup>2</sup>

<sup>1</sup>Odum Institute for Research in Social Science, University of North Carolina, Chapel Hill, NC, USA; <sup>2</sup>Division of Cardiology, Department of Medicine, University of North Carolina, Chapel Hill, NC, USA; <sup>3</sup>UNC Medical Center, Department of Medicine, University of North Carolina, Chapel Hill, NC, USA; <sup>4</sup>UNC Eshelman School of Pharmacy, PACE Division, University of North Carolina, Chapel Hill, NC, USA

Correspondence: Paul Mihas, Email [Paul\\_Mihas@unc.edu](mailto:Paul_Mihas@unc.edu)

**Introduction:** AF self-care requires patients to perform daily self-monitoring for symptoms, practice decision making to address symptom changes, and adhere to prescribed medication, diet, physical activity, and follow-up care. Technology can facilitate these critical self-care behaviors and ultimately improve patient outcomes. We assessed atrial fibrillation (AF) patients' experiences with a smartphone application (app) for AF self-management.

**Methods:** A focus group with 9 AF patients and app users was conducted and analyzed using qualitative research methods. The focus group was recorded, transcribed, and coded using a priori and inductive coding strategies. Participant responses for each code were synthesized to identify primary themes.

**Results:** We identified four superordinate themes from patients' experiences: (1) disconnect between tool and its intended use; (2) app as acknowledged tool for adherence; (3) knowledge as empowerment; (3) motives: self-interest vs supporting research. Results from this qualitative study underscore the need to clarify the app's intended use and to better accommodate patients with different AF experiences. The disconnect between a tool and its intended use can generate frustration for users.

**Discussion:** The study reinforces that participants not only see how the app is a tool for adherence; they also see knowledge they gain via the app as empowering, suggesting a correlation between app use and self-efficacy.

**Keywords:** atrial fibrillation, digital health, app, qualitative, focus group

## Introduction

Atrial fibrillation (AF) is the most common adult cardiac dysrhythmia and its incidence is increasing, with an estimated prevalence of 6–12 million patients in the US by 2030.<sup>1,2,3</sup> Outpatient management of AF is often sub-optimal,<sup>4</sup> and despite the importance of strategies to prevent stroke, one of the most serious complications of AF, nearly half of patients with AF are not adequately treated for stroke prevention.<sup>5,6</sup> Comorbidities including hypertension, obstructive sleep apnea, depression, and obesity further increase the risk of adverse patient outcomes.<sup>7,8</sup>

AF self-care requires patients to perform daily self-monitoring for symptoms, practice decision making to address symptom changes, and adhere to prescribed medication, diet, physical activity, and follow-up care. However, the 2020 World Heart Federation Roadmap on Atrial Fibrillation indicates that one priority area to address for reducing death and disability related to AF is lack of awareness of the importance of persistent adherence to oral anticoagulant (OAC) therapy.<sup>29</sup> A study evaluating long-term medication adherence patterns to direct oral anticoagulant (DOAC) therapy found that though a large proportion of patients with nonvalvular atrial fibrillation were adherent to DOAC therapy over 3.5 years, early discontinuation was associated with a higher risk of thromboembolic events.<sup>30</sup>

Technology can facilitate critical self-care behaviors and ultimately improve patient outcomes. Because of its potential applicability to the AF patient population, digital health with different digital applications (“apps”) has been increasingly used for patients with cardiac conditions, such as AF, and is being explored by an increasing number of

digital health providers.<sup>9,10</sup> One of the largest categories of digital health apps relates to medical condition management, which helps users adhere to taking medications and monitor intake.<sup>11</sup> With the increasing number of AF patients having access to mobile phones, tablets, and personal computers, digital health mobile devices could potentially be used to help deliver AF education and improve AF self-management to a growing number of patients.<sup>12</sup> Portable technologies have been utilized for the automated detection of AF.<sup>13</sup> Smartwatches and fitness bands (ie, “wearables”) can passively measure pulse rate from the wrist optical sensor.<sup>10</sup> As seen in the Apple Heart Study,<sup>10</sup> pulse data can be analyzed in real-time to assess pulse irregularity and help identify AF episodes. In other studies, digital health apps have been used to encourage AF patients to take their OAC medications. In one example, an app included what the developers called “challenges”, such as taking one’s pulse or taking an educational quiz about AF or oral anticoagulation.<sup>14</sup>

Digital health apps can encourage a more patient-centered approach to AF management, whereby the patient is more involved in reminders to take medication and participates more intentionally in building a routine to help manage their AF, such as diet and exercise, leading to improved outcomes and efficacy of the larger health system.<sup>34</sup> Stephan et al (2018) indicate that “patients with AF are likely to benefit from these strategies, due to the importance of patient ownership of decisions that require patient action, such as taking the medication and monitoring of treatment” (p. 7).<sup>16,17</sup>

Despite the potential benefits of digital health technology, patient adoption has not progressed in the way that many first expected. The reasons underlying the differential uptake of digital health technology among patients with AF are not well-understood and few studies have explicitly examined patients’ preferences for the functionalities of digital health apps, or the factors that influence their decision to use a technology-based self-management strategy versus usual care. In order to better understand the possible benefits of digital health applications specifically designed to help deliver AF education and improve AF self-care, we conducted a focus group of AF patients who were users of a digital health app developed by Pattern Health in partnership with the University of North Carolina at Chapel Hill.

## Methods

A thematic qualitative study<sup>31</sup> was conducted with a focus group of nine participants who were all users of a specific atrial fibrillation app. Some participants used the app regularly and some had stopped using it or had rarely used it. A semi-structured interview guide was used to generate discussion but also allow for participants to raise their own concerns or topics of interest. A qualitative researcher coded the data using both deductive and inductive topics.

## Sampling and Data Collection

In spring 2019, researchers at a medical center in North Carolina used purposive sampling to recruit a sample of patients with atrial fibrillation who had been introduced to an app through various channels—invitations given at AF support group meetings, in person at electrophysiology visits, or from an electronic invitation sent to all electrophysiology patients. Inclusion criteria were patients who had used and had some knowledge of the app, even if they were not regular users. 187 patients were contacted to participate, and 9 consented to participate in the focus group. Consent included specifying that participant names would not appear in any final, published report of their experiences and responses. The UNC Office of Human Research Ethics/Institutional Review Board at the University of North Carolina at Chapel Hill determined that the focus group study was exempt given that it focused on improving app functionality (IRB #19-0520).

The focus group was comprised of 6 men, 3 women, all of whom were white. Regarding age, demographics of the app users were similar to the general AF population.<sup>32</sup> One participant was in his 60s, 5 in their 70s, two in their 80s, and one in his 90s. Focus groups, rather than individual interviews, were selected to give participants the opportunity to comment on each others’ experiences. Focus groups provide opportunities for data analysis that allow for possible relational connections across participant responses. The focus group questions were semi-structured, giving participants opportunities to raise topics that mattered to them in addition to those that were part of the formal focus group guide.

## Data Analysis

The focus group audio file was transcribed, de-identified, and uploaded to a qualitative software program, MAXQDA.<sup>33</sup> An experienced qualitative researcher coded the transcripts with deductive codes, based on a priori topics as well as inductive codes, based on topics that emerged (eg, confusion). The following primary codes were analyzed: perceptions

of managing AF, reasons for using or not using the app, perceived benefits, perceptions on how data from the app will be used, confusion regarding the app, suggestions for improving the app, lack of usefulness of the app, perceptions of other technologies, educational videos, and chat features. A code summary with quotations was created for each code and used in the second phase of the analysis to generate themes related to the inductive and deductive codes. That is, patterns across codes were assessed to develop four higher-level themes, presented below. Themes addressed the dimensions of the broader deductive codes.<sup>18</sup> The codebook was reviewed and refined during the coding process. The qualitative analyst reviewed the code system and focused on the primary topics of relevance—those codes that best explained experiences, perceived benefits, and concerns—as well as co-occurrences of codes. These more focused codes and relevant code combinations became the primary findings.

## App Description

The platform for the UNC AF app, developed by Pattern Health (Durham, NC), allows partners to rapidly create a wide range of condition-specific programs that can be highly personalized based on the data collected. The University of North Carolina-Chapel Hill AF app utilized the Pattern Health platform, customized specifically for AF. The purpose of the UNC AF app was to deliver AF-specific education through videos and tips over a 4-week period and to provide tools for AF self-management and medication adherence. However, patients were able to continue using the app beyond the formal 4-week period of the study. The app was designed for use independently by AF patients. For example, patients could use the app to track biometric data (self-monitored blood pressure, heart rate); medication adherence; self-reported exercise; AF episodes and AF symptoms. The app included videos on self-management, for example, showing patients how to manually check their pulse to determine if they are in AF, what to do when they have an episode (what to do at home, when to call their doctor, when to go to the ER), and how to manage stress and anxiety related to AF. A baseline questionnaire individualized the delivery of education based on a patients' comorbidities. The app also allowed patients to invite friends or family to participate in their own plan that included education, patient adherence updates, and chat between them and the patient. See examples of app screens in [Figures 1–3](#).

## Results

Among patients who continued to use the app over 4 weeks, there was a 27% increase in adherence to self-management tasks (eg, checking blood pressure or heart rate, taking medication as prescribed, completing symptom survey). Active users completed at least one task in a plan week. Retention at week 1 was 80% while at week 4 fell to 32%.

Focus group participants had a range of experiences regarding AF itself, from being asymptomatic, feeling exhausted, to thinking they were just “getting old.” Four themes were identified: (1) disconnect between tool and its intended use; (2) app as acknowledged tool for adherence, (3) knowledge as empowerment, and (4) motives: self-interest vs using app to support research efforts.

The focus group itself was a form of education for participants and helped them understand the variation of experiences for patients with AF.

Just this conversation that we're having this morning we're seeing a wide degree of variability from individual to individual. Which I think for patient education, particularly for new people, that might be helpful for people to understand that everybody is a little bit different. (Part. 8)

Further, participants were not necessarily certain what “managing” AF meant.

How do you manage it? I mean, what do you do? If you're in A-fib, what do you do other than taking metoprolol. I mean, I'm fortunate enough I don't have—I had an ablation five-and-a-half years ago and I've had one 15-minute incident, and that's it. So I don't take meds. (Part. 2)

## Theme 1: Disconnect Between Tool and Its Intended Use

Because of the lack of clarity on how AF could be best managed in general, participants experienced some confusion regarding how the app could help in this regard. A participant who is in AF “all the time” raised a particular concern:

1:14

Search

50% Complete

### Personalize Your Plan

Get reminders and schedule your activities at times that work for you. When do you normally wake up and go to bed?

Wake Time Bed Time

8:00 AM 10:00 PM

Some activities are scheduled around meals. When do you normally eat lunch and dinner?

Lunch Time Dinner Time

12:00 PM 6:00 PM

Don't worry about getting this perfect, you can always change it later.

Next

**Figure 1** Example 1 of App Screen. Image with permission from Pattern Health. Copyright © Pattern Health, 2022.

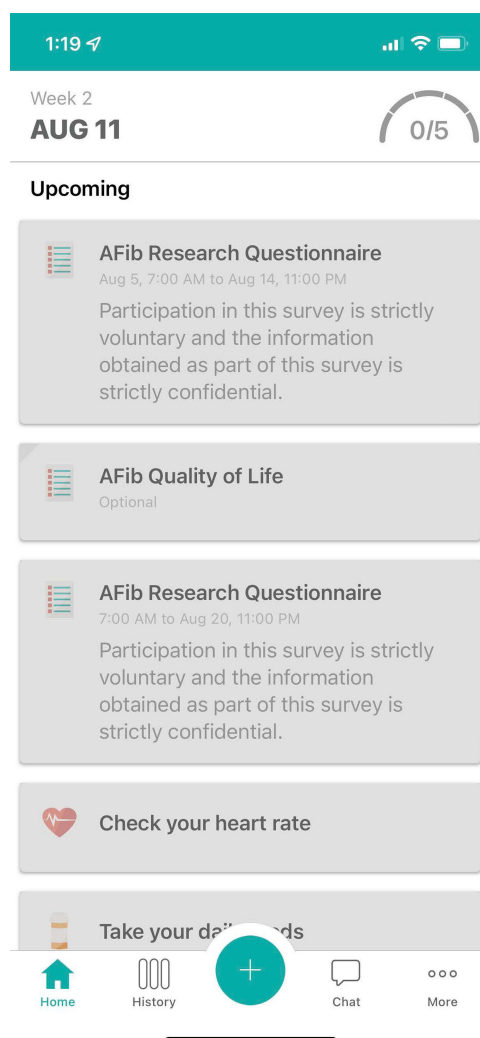
Other than just giving you the knowledge of what is happening, which some of us are aware and some of us are not, I don't understand how [the app] helps us manage .... there's definitely a disconnect there in how you're helping us manage it. (Part. 7)

Participants further indicated confusion regarding what would happen with the information from the app, whether it was a diagnostic tool or simply being used for “pure research” (Part. 3). It was not clear to participants whether or not the data from the app was going to be used by medical researchers.

That's where I think if [the cardiologist] could explain to participants what you're trying to do. I think that would help us all understand what is it supposed to be about. Is it a tool to help us manage our condition? Or is it a research tool to collect longitudinal data that may ultimately contribute to better understanding how genes work to affect your health. (Part. 2)

### Lack of Usefulness at Clinic Appointments

Some participants questioned the usefulness of the app data at clinic appointments. One complaint from several participants was that they did not think that their health care providers, such as nurses and RN assistants, were aware of the app. This points to a missed opportunity for communication between patients and providers or perhaps for using the app during appointments.



**Figure 2** Example 2 of App Screen. Image with permission from Pattern Health. Copyright © Pattern Health, 2022.

So I had my ablation in December and right after that I got an email about the app. And while the app was not that easy to download and install, I got it installed and I have been using it sort of religiously ever since. I thought that the data from the app would be useful when I went back for monthly. And it's not. Those poor nurse or RN assistants are not aware that there is an app. And that's kind of discouraging. (Part. 3)

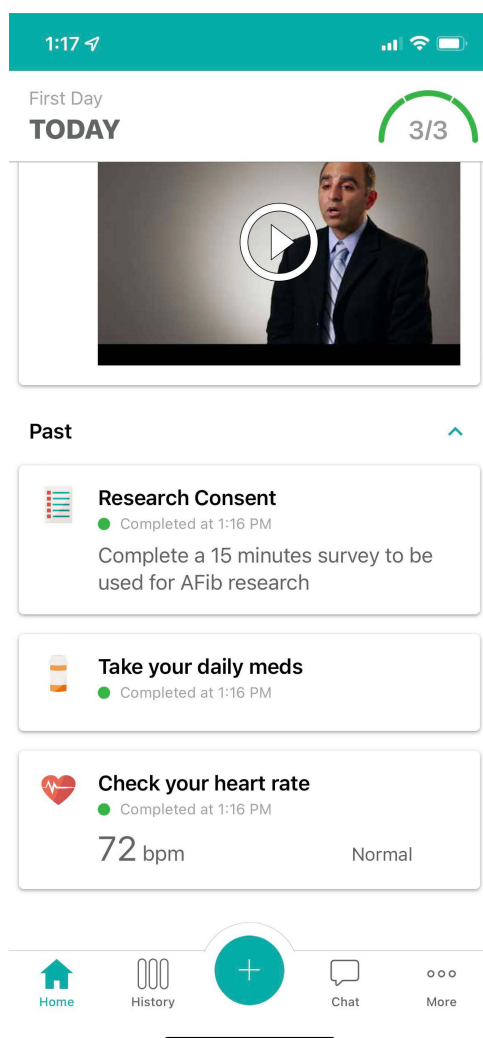
They don't know about it. (Part. 1)

## Theme 2: App as Acknowledged Tool for Adherence

In this theme, participants discussed their reasons for using the app, indicating that it functioned as a tool for adherence, such as medication reminders.

### App as Part of Patient's Plan

Participants saw the app as a tool that was “encouraging people to come up with a plan” (Part. 8). They indicated that the app could, for example, share “helpful things for me to be aware of, to help manage this, if it happens again” (Part. 2). For one participant, what at first might have felt like an emergency—going into AF—did not feel that way anymore. She suggested that the app might be used as part of a patient's plan to develop an alternative to “rushing to the emergency room” (Part. 8).



**Figure 3** Example 3 of App Screen. Image with permission from Pattern Health. Copyright @ Pattern Health, 2022.

Participants had additional positive views of what the technology could do for them.

One thing I found useful is that it reminds me to take my pulse. Because I don't have a watch. (Part. 3)

I have A-fibs occasionally. The Apple Watch woke me up during a rest period in the afternoon to tell me I had an event. Now, if the app would at this point tell me something that I should be aware of, that would be helpful. (Part. 5)

Participants suggested adding reminders about exercise, suggesting that they would like the app to provide even more features for establishing a health regimen.

### Facilitating Adherence

Some patients became consistent app users and suggested the app helped them develop self-management habits. “I have been [using] it consistently since the beginning” (Part. 2). These participants thought the app would help them know when they were in AF, functioning as an extension of their body. That is, the technological features of the app enhanced what patients could discern on their own. For example, rather than participants having to set an alarm, the app simply reminded them to take their medications, addressing fears of missing a dose. “I’m scared to death by the process of getting there [taking medications at proper intervals]” (Part. 1). Other participants expressed similar sentiments:

And I was worried because I had the ablation that I wouldn’t be able to detect it; that’s why I got the technology. (Part. 1)

So that's what it asks me every day – have you taken your morning meds? What's your heart rate? Evening meds? And of course, that's very important to a person on Tikosyn, is being religious about taking it. (Part. 6)

So it's useful to—I always like to have trends; that's why I have a Fitbit and a watch. [laughter] The more data, the better. (Part. 1)

### Barriers to Use

Some patients stopped using the app after they downloaded it because they found it confusing, too time consuming, or irrelevant to their situation. Participants mentioned the labor involved in inputting data as well as the fact that other tools, like an Apple watch, gave them basic features or sufficient information of interest.

I stopped using. I responded to the letter and I support the research, but I found there's so many notifications that weren't relevant to me and the kinds of things that I was looking for I can get with my Apple Watch. My Apple Watch woke me up from an afternoon nap, while I was resting, and said I was in heavy irregular heartbeat. (Part. 5)

I stopped using it in large part because I didn't have the time to do all the inputting .... But this constant input I just felt wasn't worth my while. (Part. 5)

### Incorporating Other Technologies

In addition to the AF app, participants mentioned other digital tools, such as Kardia and iCardio and compared their respective benefits. Some participants found these other apps useful for their “management” needs, suggesting that the AF app was not the only technology they used to obtain information and that they had to discern which app would be most helpful for their particular circumstances.

I use other apps when I'm out exercising that gather heart rate, total calories burned, things like that. Actually, what I find is that just a simple heart rate monitor, it will tell me when my heart rate is going up or down or something. So if I go into AFib, it's clear the heart rate goes way up. A simple heart rate monitor is something that will tell me if something is going wrong. (Part. 2)

## Theme 3: Knowledge as Empowerment

The perceived benefits of the app mentioned by participants included documenting personal history, educational value, and the related empowerment of being informed. For this reason, participants thought the app would be helpful at the beginning of treatment, to help them realize the “scope of impact.”

I would recommend [the app] to anybody who just starts to experience A-fib because I think with the videos that are part of the front end and the introduction, and the questions ... when I started going and answering those questions, I thought to myself, boy, *I wish I had this when I started because it would have given me a realization of the scope of the impact.* I only ever went to the hospital – well, I went twice – because of AFib. (Part. 1)

Patients should understand. If they want to take ownership of their conditions, they should understand what's going on. (Part. 2)

### Personal History

Personal “summary history” (Part. 1) was especially important to some patients, helping them value their own history and the cumulative value of their lived experience.

What I find useful about the app and why I keep dealing with the frustration of all these announcements about, it's time to do this, it's time to do that, is it collects data which I can get at .... And if I had the app [before my ablation], when [my AFib] was somewhat controlled by medication, I think it would have took care of the questions about fear and the reaction to, as well as the rest. (Part. 1)

Collecting information more regularly through the app was considered more effective than waiting several months to fill out a paper questionnaire.



I mean, previously was, what, a questionnaire that he would give me every four months. And what did I do three months ago? I couldn't remember. (Part. 2)

### Educational Videos Providing Context and Facilitating Communication

Participants who watched the educational videos on the app found them especially helpful, in some cases suggesting that they increase participant self-efficacy. The videos were also described as helpful in communicating with friends and family, regarded by one participant as “one of the biggest challenges” (Part. 8).

Those videos were really good at the front end. I thought they were great. I wish I'd had them when I started it. It would have been wonderful to provide that context. (Part. 1)

### Participant Suggestions Regarding Knowledge Building

Patients had suggestions for additional educational videos on making lifestyle changes, sharing recent research developments, and cross-referencing other patient information groups. They were also interested in the consequences of particular diagnoses, such as paroxysmal versus permanent AF and whether ablation is a “cure or is it just a way of temporarily kind of controlling things” (Part. 2). Some indicated that the app could be used to further educate people regarding specific substances and triggers of AF episodes.

But the data and actually even the— so there's one video here, I think it says there's really no connection between coffee consumption and AFib. Now, I can tell you there is. For me. And interestingly ... geneticists are identifying there are specific genes and there are variations of the genes that are associated with caffeine metabolism .... *But it would be nice to have kind of explanations of this.* What are those lifestyle factors, other than alcohol, caffeine and exercise? For me, actually, it was exercise that triggered AFib. (Part. 2)

Participants' interest in learning more about AF through groups such as StopAfib.org was another indication that being informed was of value to them.

I just found out about StopAfib.org. so why not cross-reference these different patient information groups on the app. (Part. 2)

Some participants were aware of new research findings, such as doing ablations without CT scans, or about new initiatives such as the Precision Medicine Initiative at NIH, and indicated that the app could be used to share this kind of information.

So why is it that some people are exquisitely sensitive? It could be that your alcohol metabolism genes are different than your ski buddy's. And so, that's where ultimately this type of research project can help to identify these things. And so, what does it mean? It means that you'll know more about your own individual risk. (Part. 2)

## Theme 4: Motives—Self-Interest Vs Supporting Research

Participants discussed whether it was “worth it” to provide data on the app for the sole purpose of contributing to research versus using it strictly for personal benefit. In light of this distinction, they shared differing expectations on how the app data would be used.

I approached this from the point of view that this was strictly a research app. I was not expecting to get any information back to myself. (Part. 2)

I never expected that the medical people would do anything with [the data]. Just by the nature of the questions, it seemed pretty clear to me it was trying to give you an indication. (Part. 1)

One of the difficulties that I've encountered is that the purpose of the app, first of all, wasn't explained to me. If it was an app for research, then I'd have to decide whether I want to devote the time to do it. I was looking for an app to help me with my A-fibs. And I can't spend all this time answering all these questions. (Part. 5)



I am supportive of research, really .... And so, that's my sort of real concern .... Is it diagnostic or is it just pure research? (Part. 3)

## Different Manifestations of AF

There was also discussion on whether the app was more appropriate for certain patients than others and how collective data across different kinds of patients could benefit researchers.

I would think that even if you're in permanent A-fib, there were questions around the surveys about how is it affecting your life. So I think that's where [the cardiologist] would be interested in knowing that. So if people who have paroxysmal A-fib, how does it affect your life? And if you're in permanent A-fib, what's the contrast? So I think I would encourage you to continue using it just for data collection purposes. (Part. 2)

## Providing Data for Researchers Vs Fatigue of Data Entry

Some participants indicated the potential value for research and providing better data for medical researchers, but for some patients, the data entry was too laborious.

So it'd be really interesting to begin to explore the environmental as well as genetic parameters predisposed to this. So having good data, even if you're in permanent A-fib, would be, I think, useful for a research project. (Part. 2)

I really wanted to support the research part, but it just got to be too much. (Part. 7)

A few participants discussed more specifically how the app could be used in precision medicine.

In the era now of precision medicine, ultimately our genomes are going to be sequenced. So I'm assuming that this is going to be hugely valuable data you can ultimately correlate variations of genes to people who develop paroxysmal A-fib or people who then go into permanent A-fib. So that was just my expectation. But I think just in terms of data collection, having clinical samples, the quality of data collection now with mobile apps improves the quality of the material that [the cardiologist] has to work with. (Part. 2)

## Future Directions

Participants described the app as a tool that still felt as if it were in development.

It had that feeling of a new app. And it had that feeling of, we are kind of working things out. And it had that feeling of, there are a lot of really busy people involved in this project and nobody is really in charge of it. (Part. 8)

In light of the app being in an early phase of development, participants offered suggestions for improving it, including being able to customize the timing of the reminders, connecting the app to other devices, adding reminders about exercise, bolstering support features for troubleshooting difficulties, and using the data to accelerate precision medicine research.

Participants discussed the timing of the survey feature and would also like the app to let the patient choose the time of reminders.

You are more likely to get data from me if you change it so I can enter it in the morning. (Part. 3)

So the answer is they should set it so that you can choose how often and when you want to see it. (Part. 7)

Not everybody wants to be reminded twice a day. But if it's not possible to unremind it today, is that right? There's no app for that yet. (Part. 1)

Connecting the AF app to Apple products was another suggestion.

## Discussion

Results from this qualitative study underscore the need to clarify an app's intended use when presenting it to patients and to better understand how patients with different AF experiences—from infrequent to “constant”—might use the

app differently. Other AF apps have considered patients in different stages of adherence. In a “motivational patient assistant” app for AF management, Peleg et al<sup>19</sup> customized educational material and behavioral modification interventions according to the patient’s stage in the Transtheoretical Model (TTM): contemplation (patient considers change), preparation (plans to take action), action (begins to change), and maintenance (succeed in incorporating new behaviors in lifestyle). This customization might better serve a range of AF patients in various stages of adherence.

Our study also reinforces that patients not only see the app as a tool for adherence but also one that can increase knowledge and thereby, for some patients, self-efficacy as well. Other studies show similar results. In a randomized control trial, an intervention arm utilized a mobile AF (mAF) app designed to incorporate clinical decision-support tools, educational materials, and patient involvement strategies. More than 90% of patients reported that the mAF app was easy, user-friendly, and associated with improvements in knowledge compared to the usual care arm.<sup>20</sup> The Pattern Health app in our study, by including knowledge-building features such as educational videos, also suggests links to improved communication.

Other studies of AF apps generate additional topics of concern. In a study of 12 AF mobile apps available in consumer app stores, researchers found that more than half of the apps had below average quality and most offered “only a few distinct functionalities” (p. 40), suggesting considerable room for improvement in the development of mobile AF apps.<sup>21</sup> A study of 14 apps available for AF showed that most apps were aimed at users having a reading-grade level beyond high school education,<sup>22</sup> though our study did not show any issues with limited general or health literacy. Further studies would be needed with participants of different education levels to assess the recommended literacy level for AF apps.

Anderson et al<sup>23</sup> found that mobile health apps that sustain positive behaviors and adapt to changes in consumer requirements were more likely to be used on a continual basis. As in the current study, Anderson et al found a range of interests from the participants. Some participants were particularly interested in statistics and used their data in a more advanced way while others simply accessed basic graphs and charts. Desteghe et al<sup>14</sup> found the need to make their particular AF app more “varied, stimulating, and challenging as app use was lower than expected and decreased over time in patients” (“Discussion”, para. 4). Similarly in our study, retention fell to 32% in week 4; not knowing how the data would be used made it difficult for some participants to decide whether to invest in the “inputting” required and attention to numerous, and sometimes irrelevant, notifications. As in the Desteghe et al study, patients in our study reported that the educational aspect was particularly beneficial.

Our findings support the benefit of apps in promoting medication and behavioral adherence, which, as other studies have shown, can be assisted through a larger canvas of approaches—electronic monitoring feedback, behavioral counseling, and patient education.<sup>24,25</sup> Hirschey et al<sup>26</sup> found that participants responded positively to the medication reminder feature in a digital AF app. Similar to our study, they found that many individuals experienced uncertainty about how particular features functioned. However, there was less uncertainty in Hirschey et al regarding the purpose of the app. In both studies, participants suggested that the app’s usefulness is tied to how well the design matches the patient’s daily schedule of taking medication and exercise. Though participants in our study did not generally connect education to adherence, Peleg et al<sup>19</sup> found that increasing adherence through education is “necessary to affect heavier modifications”, and motivation for behavior modification is sustained when patients know, for example, how and why a new way of anticoagulation is necessary (p. 8). This study underscores the potential value of an app that has multiple features, such as managing self-care, medical adherence, and exercise, rather than downloading separate apps for each of these.

## Strengths and Limitations

A strength of this study is that it combined both deductive topics and inductive topics, the latter underscoring what mattered most to participants in their own words. The study also deliberately included a broad range of app users—from brief users to regular users—and having participants of different technical skills levels share experiences with each other created a rich discussion regarding what was meaningful and how they made sense of digital technology. A limitation of the study is that only white patients were included. Also, because only one focus group was conducted, we were not able to reach theoretical saturation. Because the focus group comments were specific to our app, which was still in its first

phase of development, it is difficult to know if the findings are applicable to the use of apps for AF management in general.

## Conclusions and Future Directions

Although there is great potential for the use of digital health apps in the chronic management of patients with AF, there is considerable development necessary before such products can be distributed for routine use. Future app designs and implementations would benefit from a “human-factors approach” or “user-centered design.”<sup>27,28</sup> Toscos et al<sup>34</sup> used a user-centered design to engage patients in AF management via educational messaging, nudging, and timing that were tailored according to a user-centered design. Of similar interest, Peleg et al<sup>19</sup> and Hibbard et al<sup>15</sup> both identify four stages that patients go through to become increasingly “competent managers of their own health”<sup>15</sup> (p. 1445). Peleg et al<sup>19</sup> discuss how their stage-based tool uses education such that patients become more “competent to effectively manage their disease at home” (p. 234). Future studies can assess the specific connection between education via app use and AF management competencies. Future direction can also explore how apps can help patients move through identifiable phases, playing an increasingly active role in their own health.

## Disclosure

Ms Tiffany Armbruster reports grants from Bristol Myers Squibb Foundation, during the conduct of the study. Ms Jennifer Walker research salary support from Bristol Myers Squibb Foundation, during the conduct of the study. Dr Anil Gehi reports grants from Bristol Myers Squibb Foundation; speaker’s honoraria, consulting fees from Abbott, Zoll Medical, Biotronik, and iRhythm, outside the submitted work. The authors report no other conflicts of interest in this work.

## References

1. Miyasaka Y, Barnes ME, Gersh BJ, et al. Secular trends in incidence of atrial fibrillation in Olmsted County, Minnesota, 1980 to 2000, and implications on the projections for future prevalence. *Circulation*. 2006;114(2):119–125. doi:10.1161/CIRCULATIONAHA.105.595140
2. Naccarelli GV, Varker H, Lin J, Schulman KL. Increasing Prevalence of Atrial Fibrillation and Flutter in the United States. *Am J Cardiol*. 2009;104(11):1534–1539. doi:10.1016/j.amjcard.2009.07.022
3. Colilla S, Crow A, Petkun W, Singer DE, Simon T, Liu X. Estimates of current and future incidence and prevalence of atrial fibrillation in the U.S. adult population. *American J Cardiol*. 2013; 112(8):1142–7. doi:10.1016/j.amjcard.2013.05.063
4. Singh SN. Costs and clinical consequences of suboptimal atrial fibrillation management. *Clin Economics Outcomes Res*. 2012;4(1):79–90. doi:10.2147/CEOR.S30090
5. Hsu JC, Maddox TM, Kennedy KF, et al. Oral Anticoagulant Therapy Prescription in Patients With Atrial Fibrillation Across the Spectrum of Stroke Risk: insights From the NCDR PINNACLE Registry. *JAMA Cardiol*. 2016;1(1):55–62. doi:10.1001/jamacardio.2015.0374
6. Piccini JP, Hernandez AF, Zhao X, et al. Quality of care for atrial fibrillation among patients hospitalized for heart failure. *J Am Coll Cardiol*. 2009;54(14):1280–1289. doi:10.1016/j.jacc.2009.04.091
7. Ling LH, Kistler PM, Kalman JM, Schilling RJ, Hunter RJ. Comorbidity of atrial fibrillation and heart failure. *Nat Rev Cardiol*. 2016;13(3):131–147. doi:10.1038/nrcardio.2015.191
8. Heijman J, Linz D, Schotten U. Dynamics of atrial fibrillation mechanisms and comorbidities. *Annu Rev Physiol*. 2021;83:83–106. doi:10.1146/annurev-physiol-031720-085307
9. Nilsen W, Kumar S, Shar A, et al. Advancing the science of mHealth. *J Health Commun*. 2012;17(SUPPL. 1):5–10. doi:10.1080/10810730.2012.677394
10. Turakhia MP, Desai M, Hedlin H, et al. Rationale and design of a large-scale, app-based study to identify cardiac arrhythmias using a smartwatch: the Apple Heart Study. *Am Heart J*. 2019;207:66–75. doi:10.1016/j.ahj.2018.09.002
11. Research2guidance. *mHealth App Economics 2017/2018: Current Status and Future Trends in Mobile Health*. 2018:1–26
12. Pew Research Center. Demographics of Mobile Device Ownership and Adoption in the United States \_ Pew Research Center; 2021. <https://www.pewresearch.org/internet/fact-sheet/mobile/June12>. Accessed March 16, 2022.
13. Lau JK, Lowres N, Neubeck L, et al. iPhone ECG application for community screening to detect silent atrial fibrillation: a novel technology to prevent stroke. *Int J Cardiol*. 2013;165(1):193–212. doi:10.1016/j.ijcard.2013.01.220
14. Desteghe L, Kluts K, Vijgen J, et al. The health buddies app as a novel tool to improve adherence and knowledge in atrial fibrillation patients: a pilot study. *JMIR Mhealth and Uhealth*. 2017;5(7):e98. doi:10.2196/mhealth.7420
15. Hibbard JH, Mahoney ER, Stock R, Tusler M. Do increases in patient activation result in improved self-management behaviors? *Health Serv Res*. 2007;42(4):1443–1463. doi:10.1111/j.1475-6773.2006.00669.x
16. Seaburg L, Hess EP, Coylewright M, Ting HH, McLeod CJ, Montori VM. Shared decision making in atrial fibrillation where we are and where we should be going. *Circulation*. 2014;129(6):704–710. doi:10.1161/CIRCULATIONAHA.113.004498
17. Stephan LS, Almeida ED, Guimarães RB, et al. Oral anticoagulation in atrial fibrillation: development and evaluation of a mobile health application to support shared decision-making. *Arq Bras Cardiol*. 2018;110(1):7–15. doi:10.5935/abc.20170181
18. Miles MB, Huberman AM, Saldana J. *Qualitative Data Analysis*. 4th ed. SAGE; 2020.

19. Peleg M, Michalowski W, Wilk S, et al. Ideating Mobile Health Behavioral Support for Compliance to Therapy for Patients with Chronic Disease: a Case Study of Atrial Fibrillation Management. *J Med Syst.* 2018;42(11). doi:10.1007/s10916-018-1077-4
20. Guo Y, Chen Y, Lane DA, Liu L, Wang Y, Lip GYH. Mobile Health Technology for Atrial Fibrillation Management Integrating Decision Support, Education, and Patient Involvement: mAF App Trial. *Am J Med.* 2017;130(12):1388–1396.e6. doi:10.1016/j.amjmed.2017.07.003
21. Turchioe MR, Jimenez V, Isaac S, Alshalabi M, Slotwiner D, Creber RM. Review of mobile applications for the detection and management of atrial fibrillation. *Heart Rhythm O2.* 2020;1(1):35–43. doi:10.1016/j.hroo.2020.02.005
22. Ayyaswami V, Padmanabhan DL, Crihalmeanu T, Thelmo F, Prabhu A, Magnani JW. Mobile health applications for atrial fibrillation: a readability and quality assessment. *Int J Cardiol.* 2019;293:288–293. doi:10.1016/j.ijcard.2019.07.026
23. Anderson K, Burford O, Emmerton L. Mobile health apps to facilitate self-care: a qualitative study of user experiences. *PLoS One.* 2016;11(5). doi:10.1371/journal.pone.0156164
24. Demonceau J, Ruppert T, Kristanto P, et al. Identification and assessment of adherence-enhancing interventions in studies assessing medication adherence through electronically compiled drug dosing histories: a systematic literature review and meta-analysis. *Drugs.* 2013;73(6):545–562. doi:10.1007/s40265-013-0041-3
25. Mahtani KR, Heneghan CJ, Glasziou P, Perera R. Reminder packaging for improving adherence to self-administered long-term medications. *Cochrane Database Sys Rev.* 2011;9:1–53. doi:10.1002/14651858.CD005025.pub3
26. Hirschey J, Bane S, Mansour M, et al. Evaluating the usability and usefulness of a mobile app for atrial fibrillation using qualitative methods: exploratory pilot study. *JMIR Human Factors.* 2018;5(1):e13. doi:10.2196/humanfactors.8004
27. Dabbs ADV, Myers BA, Mc Curry KR, et al. User-centered design and interactive health technologies for patients. *Computers Informatics Nursing.* 2009;27(3):175–183. doi:10.1097/NCN.0b013e31819f7c7c
28. Tran K, Leblanc K, Valentinis A, Kavanagh D, Zahr N, Ivers NM. Evaluating the usability and perceived impact of an electronic medical record toolkit for atrial fibrillation management in primary care: a mixed-methods study incorporating human factors design. *JMIR Human Factors.* 2016;3(1):e7. doi:10.2196/humanfactors.4289
29. Freedman B, Hindricks G, Banerjee A, et al. World Heart Federation Roadmap on Atrial Fibrillation—A 2020 Update. *Glob Heart.* 2021 May 27;16(1):41. doi:10.5334/gh.1023
30. An J, Bider Z, Luong TQ, et al. Long-term medication adherence trajectories to direct oral anticoagulants and clinical outcomes in patients with atrial fibrillation. *J Am Heart Assoc.* 2021 Nov 2;10(21):e021601. doi:10.1161/JAHA.121.021601
31. Braun, V., Clarke, V. Using thematic analysis in psychology. *Qualitative Research in Psychology.* 2006;3(2):77–101. doi:10.1191/1478088706qp063oa
32. Kornej J, Börschel CS, Benjamin EJ, Schnabel RB. Epidemiology of atrial fibrillation in the 21st century: Novel methods and new insights. *Circulation Research.* 2020;127:4–20. doi:10.1161/CIRCRESAHA.120.316340
33. VERBI Software. (2021). MAXQDA 2022 [computer software]. Berlin, Germany: VERBI Software. Available from: [maxqda.com](http://maxqda.com). Accessed September 27, 2022.
34. Toscos T, Coupe A, Wagner S, et al. Engaging patients in atrial fibrillation management via digital health technology: The impact of tailored messaging. *J Innov Cardiac Rhythm Manage.* 2020;11(8):4209–4217. doi:10.19102/icrm.2020.110802

## Patient Preference and Adherence

Dovepress

### Publish your work in this journal

Patient Preference and Adherence is an international, peer-reviewed, open access journal that focusing on the growing importance of patient preference and adherence throughout the therapeutic continuum. Patient satisfaction, acceptability, quality of life, compliance, persistence and their role in developing new therapeutic modalities and compounds to optimize clinical outcomes for existing disease states are major areas of interest for the journal. This journal has been accepted for indexing on PubMed Central. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/patient-preference-and-adherence-journal>