Abstract

**Background:** mHealth, or the use of mobile technology to support the achievement of health objectives, has the potential to revolutionize heart failure (HF) self-management. However, the potential benefits from mHealth can only be realized through its adoption. Hence, a better understanding of the factors that influence mHealth adoption could guide the development and implementation of mHealth-based HF interventions. The purpose of this dissertation was to examine facilitators and barriers that influence intention to adopt mHealth among older people with HF.

**Methods:** To systematically investigate the factors that influence mHealth adoption, a cross-sectional, explanatory sequential mixed-methods design was used guided by the Technology Acceptance Model (TAM). Convenience sampling was used to recruit participants from Johns Hopkins Hospital and online (Qualtrics) for the quantitative phase of the study. Participants responded to a 52-item self-report questionnaire, which included a modified TAM scale and the eHealth Literacy scale (eHEALS). In-person participants were then purposively sampled for the qualitative phase of the study. Semi-structured interviews were conducted using interview guides tailored to the participant’s response to the questionnaire.

**Results:** A total of 129 older adults with HF participated in the study. And a subsample of 10 participants was interviewed for the qualitative phase. Social influence ($\beta=0.17$, $P=0.010$), perceived ease of use ($\beta=0.16$, $P<0.001$), and perceived usefulness ($\beta=0.33$, $P<0.001$) were significantly associated with intention to use mHealth even after controlling for potential confounders (age, gender, race, education, income, and smartphone use). The following themes emerged from the content analysis of the
interview transcripts: (facilitators) previous experience with mobile technology, willingness to learn mHealth, ease of use, presence of useful features, adequate training, free equipment, and doctor’s recommendation; (barriers) lack of knowledge regarding how to use mHealth, decreased sensory perception, lack of need for technology, poorly-designed interface, cost of technology, and limited/fixed income.

**Conclusion:** Overall, the findings suggest that older adults are willing to use mHealth albeit not without reservations. Future researchers looking to implement mHealth-based interventions should address the person-related, technology-related, and contextual barriers, at the same time capitalize on the influence of potential facilitators.

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I am the middle of three sisters. With no brothers to ‘carry on the family name’, I once promised my father that he was going to have a Dr. Cajita nonetheless. So when my older sister got married before she got her PhD, I knew it was up to me to fulfill the promise.

*Tay naa na gyud kay Dr. Cajita! 😊*

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CHAPTER 1
Background

In the United States, it is estimated that 3.9 million older adults have heart failure (HF).\textsuperscript{1} This number is only expected to increase with the aging of the population.\textsuperscript{2} Not only is HF prevalent, it is also very costly to treat. The total cost of treating HF is projected to increase from $30.7 billion in 2012 to $69.8 billion in 2030, the majority (80%) of which is spent on hospitalizations\textsuperscript{3}. Over 70% of the estimated 1 million HF-related hospitalizations were for those aged 65 and over.\textsuperscript{4}

Effective HF self-management is the key to reducing the skyrocketing healthcare costs associated with treating HF. HF self-management lowers HF-related costs by decreasing unnecessary rehospitalizations.\textsuperscript{5,6} However, HF self-management is complex and patient nonadherence to recommended treatment plans is common, especially among older people,\textsuperscript{7} who often have multiple comorbid conditions and are prescribed multiple medications, which add to the complexity of HF self-management.\textsuperscript{8,9} HF self-management involves adherence to medications, low sodium diet, regular exercise, and symptom monitoring and management.\textsuperscript{10}

mHealth, or the use of mobile technologies in the delivery of healthcare services to support the achievement of health objectives,\textsuperscript{11} offers a potential solution to patient nonadherence. It can provide people with HF with increased support, knowledge, and access to healthcare providers, which would empower them to effectively manage their HF.\textsuperscript{12} Additionally, the popularity of the mobile phone and similar mobile devices, coupled with their rapidly increasing computing capabilities, make them an ideal tool for delivering health care. mHealth has been utilized in managing other chronic diseases such as diabetes,\textsuperscript{13,14} hypertension,\textsuperscript{15,16} and chronic obstructive pulmonary disease\textsuperscript{17}; wherein,
it has been shown to decrease HbA1c, decrease blood pressure, and improve exercise capacity, respectively. However, mHealth is only useful if it is used; hence, the need to examine factors that facilitate or inhibit mHealth adoption in order to inform the design of mHealth HF interventions.

Over the recent years there has been a steady increase in the number of studies exploring technology adoption/acceptance among older adults; however, few have focused on mobile technologies and even fewer have explored the acceptability of using mobile technology for health-related purposes. Furthermore, none of the studies examined older adults’ perceptions of mHealth for HF or chronic disease self-management. A better understanding of the facilitators and barriers that could influence older adults’ intention to adopt mHealth for HF self-management could guide the development and implementation of future mHealth-based HF interventions.

**Purpose and Specific Aims**

Therefore, the purpose of this dissertation study was to examine facilitators and barriers that influence intention to adopt mHealth among older people with HF. In order to systematically investigate the characteristics and perceptions of older people with HF, a cross-sectional, explanatory sequential mixed-methods design was used guided by the Technology Acceptance Model. The specific aims of the study were as follows:

**Quantitative Aims:**

1. Examine the relationship between eHealth literacy, social influence, and perceptions about mHealth (usefulness and ease of use) in older people with HF.
Hypothesis 1.1: eHealth Literacy is positively associated with Perceived Ease of Use of mHealth even after adjusting for age, gender, race, education, income, and smartphone ownership.

Hypothesis 1.2: Social Influence is positively associated with Perceived Usefulness of mHealth even after adjusting for age, gender, race, education, income, and smartphone ownership.

Hypothesis 1.3: Perceived Ease of Use is positively associated correlated with Perceived Usefulness even after adjusting for age, gender, race, education, income, and smartphone ownership.

2. Examine the relationship between perceptions about mHealth (usefulness, ease of use, and financial cost) and intention to use mHealth in older people with HF.

Hypothesis 2.1: Perceived Ease of Use is positively associated with Behavioral Intention (intention to use mHealth) even after adjusting for age, gender, race, education, income, and smartphone ownership.

Hypothesis 2.2: Perceived Usefulness is positively associated with Behavioral Intention (intention to use mHealth) even after adjusting for age, gender, race, education, income, and smartphone ownership.

Hypothesis 2.3: Perceived Financial Cost is negatively associated with Behavioral Intention (intention to use mHealth) even after adjusting for age, gender, race, education, income, and smartphone ownership.

3. Examine for the presence of effect modification and mediation

Hypothesis 3.1: Perceived Ease of Use moderates the relationship between Perceived Usefulness and Behavioral Intention (intention to use mHealth).
Hypothesis 3.2. Perceived Ease of Use mediates the impact of eHealth Literacy on Behavioral Intention (intention to use mHealth)

Hypothesis 3.3. Perceived Usefulness mediates the impact of Social Influence on Behavioral Intention (intention to use mHealth)

Qualitative Aim:
4. Explore perceptions regarding mHealth in older people with HF, specifically on the following topics: (a) ease of use, (b) usefulness of mHealth, (c) interest in adopting mHealth, and (d) facilitators and barriers to adoption of mHealth.

Mixed Methods Aim:
5. To describe and compare the facilitators and barriers that influence intention to adopt mHealth between older people with HF with varying degrees of intention to use mHealth (high, moderate, low).

Conceptual Framework

An adapted Technology Acceptance Model (TAM)²⁵ was used to guide the study. The TAM was used to inform what constructs were measured in the quantitative phase of the study. Additionally, the participants, who were interviewed for the qualitative phase of the study, were purposively selected based on their responses to the TAM-Behavioral Intention subscale.

Technology Acceptance Model (TAM)

The TAM was first proposed by Dr. Fred Davis in 1985.²⁷ Derived from the Theory of Reasoned Action, the TAM has undergone multiple modifications before its latest version, which was presented by Venkatesh and Davis in 1996.²⁸ The model adapted for this study was based on the latest version of the TAM. The model posits that
the strongest predictor of technology use is behavioral intention, which is in turn influenced by the individual’s perceived ease of use and perceived usefulness.\textsuperscript{27} Even in its most parsimonious version, the TAM has been shown to account for 30-40\% of technology acceptance.\textsuperscript{29–31} In healthcare, TAM has been shown to explain from 30\%\textsuperscript{32} to 70\%\textsuperscript{33,34} of the variance in the acceptance of health technologies.

While the parsimonious TAM explains a considerable amount of the variance in technology acceptance, previous studies have shown that the addition of select constructs further improves its predictive ability;\textsuperscript{35} therefore, additional constructs (eHealth Literacy, Social Influence, and Perceived Financial Cost), selected based on a review of relevant literature, were added to the model.

![Figure 1. Modified Technology Acceptance Model](image)

**Main constructs**

**Perceived Usefulness (PU)**

Perceived Usefulness is defined as the “degree to which a person believes that using a particular technology will enhance his performance”.\textsuperscript{36} To better reflect the study population and the purpose of the technology, PU was conceptually defined as the degree
to which the person with heart failure believes that using mHealth will enhance the management of his heart failure. In previous studies, PU has been consistently shown to be significantly associated with intention to use technology and is thought to be the most important predictor of technology acceptance.20,33–35,37–44

Perceived Ease of Use (PEOU)

Perceived Ease of Use is conceptually defined as the “degree to which a person [with heart failure] believes that using a [mHealth] would be free of effort”.36 Although not as consistent as PU, PEOU has also been shown to be associated with intention to use behavioral intention in several studies.20,33,34,37,38,40–45 Additionally, PEOU has been shown to be associated with PU or that PU mediates the effect of PEOU on behavioral intention.20,41,43,44,46–48

Behavioral intention (BI)

Behavioral Intention is conceptually defined as the intention to use mHealth in the context of heart failure self-management. Being more proximal than the actual use of technology, BI is often the outcome of choice for the majority of the TAM-guided studies. In longitudinal studies that actually measured actual use, BI has been shown to significantly predict actual use of technology.49–53

Additional constructs

Social Influence

Social Influence, also referred to as subjective norms, is defined as “a person’s perception that most people who are important to him/her think that he/she should perform the behavior in question”,20,35 which in this case is technology adoption.
Previous studies have shown that older adults are susceptible to the effects of social influence when it comes to technology acceptance.20,44,54

*eHealth Literacy*

Previous studies have identified eHealth Literacy as a significant predictor of health-related technology use.55–57 eHealth literacy is defined as “*the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem*”.58 Higher eHealth literacy has been found to be associated with higher perceived self-efficacy in using health-related mobile apps55 and higher confidence in seeking health-related information online.56,57 Finally, one study found that eHealth literacy was associated the adoption of a physician-rating mobile app.40

*Perceived Financial Cost*

Commonly retired from the workforce, older adults tend to rely on a limited amount of income; hence, the cost of the technology has been found to be an important determinant of technology adoption.18,59 Perceived financial cost has been found to be significantly negatively correlated to behavioral intention.33
CHAPTER 2
A systematic review of mHealth-based heart failure interventions

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Abstract

Background—The popularity of mobile phones and similar mobile devices makes it an ideal medium for delivering interventions. This is especially true with heart failure (HF) interventions, in which mHealth-based HF interventions are rapidly replacing their telephone-based predecessors.

Purpose—This systematic review examined the impact of mHealth-based HF management interventions on HF outcomes. The specific aims of the systematic review are to: (1) describe current mHealth-based HF interventions and (2) discuss the impact of these interventions on HF outcomes.

Methods—PubMed, CINAHL Plus, Embase, PsycINFO, and Scopus were systematically searched for randomized controlled trials or quasi-experimental studies that tested mHealth interventions in people with HF using the terms Heart Failure, Mobile Health, mHealth, Telemedicine, Text Messaging, Texting, Short Message Service, Mobile Applications, and Mobile Apps.

Conclusions—Ten articles, representing nine studies, were included in this review. Majority of the studies utilized mobile health technology as part of a HF monitoring system, which typically included a blood pressure measuring device, weighing scale, and an ECG recorder. The impact of the mHealth interventions on all-cause mortality, cardiovascular mortality, HF-related hospitalizations, length of stay, NYHA functional class, LVEF, quality of life, and self-care were inconsistent at best.

Implications—Further research is needed to conclusively determine the impact of mHealth interventions on HF outcomes. The limitations of the current studies (e.g. inadequate sample size, quasi-experimental design, use of older mobile phone models, etc.) should be taken into account when designing future studies.

Keywords
Heart failure; mHealth; mobile health; telemedicine; text messaging
Background

In the United States, 5.1 millions adults have heart failure (HF) and approximately $31 billion are spent annually in HF-related costs. The majority of HF-related costs are attributed to hospitalizations, which are most often the result of poor HF self-management. The complexity of HF self-management contributes to the poor adherence to recommended HF treatment plans and, ultimately, to frequent hospitalizations.

Telemedicine, or the use of information and communication technology to bridge the distance barrier in order to improve health outcomes, was first coined in the 1970s. In cardiology, early forms of telemedicine involved the transmission of electrocardiograph data over telephone lines. In HF management, the use of technology in monitoring patients’ conditions remotely or telemonitoring, were first tested in the late 1990s. Eventually, as technology evolved so did its health-related applications.

As mobile phones became more ubiquitous, researchers started to turn their attention to the utility of mobile phones and similar portable devices in health-related interventions. It is estimated that 90% of adult Americans have mobile phones and 58% have smartphones. The popularity of the mobile phone and its rapidly increasing computing capabilities, makes it an ideal tool for delivering health care. mHealth, or the use of mobile technologies in the delivery of healthcare services to support the achievement of health objectives, first appeared in publication in 2003 and has since seen an exponential increase in usage. mHealth has been utilized in managing other chronic diseases such diabetes, hypertension, and chronic obstructive pulmonary disease; wherein, it has been shown to decrease HbA1c, decrease blood pressure, and increase exercise capacity, respectively.

While there have been several systematic reviews of the use of technology in HF management they were focused on older telephone-based technology, which, with the advent of the mobile phone, has been rendered near obsolete. Therefore a systematic review focusing on current mobile health technology is warranted. The purpose of this systematic review is to examine the impact of HF management interventions using mHealth technology on HF outcomes. Specifically, this systematic review aims to (1) describe current mHealth-based HF interventions and (2) discuss the impact of these interventions on HF outcomes.

Methods

Five databases (PubMed, CINAHL Plus, Embase, PsycINFO, and Scopus) were systematically searched for relevant studies with the help of a medical librarian. The following search terms were used: Heart Failure, Cardiac Failure, Heart Decompensation, Myocardial Failure, Congestive Heart Failure, Mobile Health, mHealth, Telemedicine, Text Messaging, Texting, Short Message Service, Text Messages, Mobile Applications, Mobile Apps, and Mobile App. Studies were included if they met the following criteria: (1) used a randomized control trial or a quasi-experimental design, (2) tested an intervention using a mobile device (by itself or as part of a system), (3) included HF patients ≥18 years, and (4)
published in English. Studies were excluded if they tested a traditional telephone-based HF intervention and only had abstracts or study protocols available. Only relevant articles published before June 5, 2015 were included in this systematic review.

The initial database search yielded 1882 citations. After the predefined filters (i.e. age, language) were applied, 706 citations remained. 488 abstracts remained after duplicates were removed and were then subsequently reviewed for their relevance. Following the abstract review, full-text evaluations of the remaining 77 articles were conducted, which resulted in the inclusion of 9 articles. A manual search of the references of the included articles yielded 1 additional relevant study. A total of 10 articles, representing 9 studies (i.e. two articles\textsuperscript{19,20} were on the same intervention but reported on different outcomes), were included in this systematic review (Figure 1).

The Cochrane Collaboration’s tool for assessing risk of bias was used to appraise the rigor of the included studies.\textsuperscript{21} The tool assesses for risk of selection bias, performance bias, detection bias, attrition bias, and reporting bias. Risk assessments can be presented in the form of a pictograph and/or a table containing the risk ratings (high risk, low risk, or unclear risk) alongside the reviewers’ rationales.\textsuperscript{21} Two reviewers independently assessed the rigor of the included studies with a 91% agreement rate (Kappa 0.86, \(P < 0.001\)); discrepancies were discussed then reconciled. Inter-rater agreement was calculated using Stata 13 (StataCorp LP, College Station, Texas, USA). The first author performed the data extraction and the second author reviewed the data extraction table for accuracy. The heterogeneity of the mHealth interventions and the measured outcomes (i.e. all-cause/cardiovascular mortality, HF hospitalizations, length of stay, New York Heart Association (NYHA) functional class, left ventricular ejection fraction (LVEF), quality of life, and self-care) precluded the conduct of a meta-analysis; hence, a systematic review with descriptive synthesis was performed and quantitative results from the individual studies are presented to support the narrative.

**Results**

Key characteristics of the included studies are summarized in Table 1. Six of the nine studies included in this review were randomized control trials and the remaining studies utilized a quasi-experimental design. Only three of the studies reported the racial composition of their study sample (overall, 68% White, 18% Black, 14% other race) and all were conducted in North America.\textsuperscript{22–24} The remaining 6 studies were conducted in Europe and Australia. Study duration ranged from 4 weeks to 24 months. The number of study participants ranged from 6 to 710 totaling 1777 participants. The mean age of the study participants was 61.3 years. The majority of the study participants (81.1%) were male. The mean LVEF of the study samples was 29.1%. On average, <1% of the study participants were in NYHA functional class I, 44.5% were in class II, 53.7% were in class III, and the remaining 1.5% were in class IV.

The results of the bias risk assessments are depicted in Figure 2 and Figure 3. Overall, the methodological rigor of the included studies was moderate. Although two studies\textsuperscript{19,20,25} had low risk of bias in all categories, majority of the studies had a high risk for bias in at least
one bias category. Additionally, majority of the studies failed to provide enough information to allow for a complete assessment of their risk of bias (i.e. unclear risk of bias).

**Characteristics of Current mHealth Interventions**

Key characteristics of the mHealth interventions are summarized in Table 2. The majority of the studies (8 of 9) used mobile devices as part of a larger HF monitoring system, which typically included a blood pressure measuring device, electrocardiogram (ECG) recorder, or an implantable defibrillator equipped with a heart rhythm monitoring function. Only one study used mHealth as a stand-alone intervention. Nundy et al. used the mobile phone to deliver daily HF education messages to their study participants via text messaging. In the studies, various mediums were used to transmit data including mobile phones (n=5), small wireless devices (n=2), or tablets (n=2).

Seven of the eight mHealth monitoring systems utilized a central monitoring center/platform; five allowed for automatic data transfer between the participants and the monitoring center, while the remaining two required the participants to manually input and transfer their data to the monitoring center. Four of the monitoring systems utilized algorithms to determine whether the patients’ values were outside their predefined limits, which would then trigger an alert message to be sent to the participants’ physicians. Meanwhile, two of the studies had trained nurses and physicians in their central monitoring centers who regularly monitored the participants’ status. The remaining study did not specify who/what performed the data monitoring. Additionally, only three of the studies utilized a structured approach in contacting participants regarding their status, the remaining studies made it optional for the physicians to contact their patients.

**Impact of mHealth Interventions on HF Outcomes**

Table 3 summarizes the impact of the mHealth interventions on HF outcomes assessed in two or more studies including mortality (all-cause and cardiovascular specific), HF hospitalizations, length of stay, NYHA functional class, LVEF, quality of life, and self-care. Outcomes that were measured in only one study (e.g. walked distance, perceived exertion, b-type natriuretic peptide level) were not selected due to the limitation in comparing findings across studies. The impact of the mHealth interventions on all-cause mortality was mixed. One study reported a lower mortality rate for the intervention group (hazard ratio 0.36, 95% confidence interval 0.17–0.74, \( P=0.004 \)), while another study had no difference in mortality rates between their study groups (hazard ratio 0.97, 95% confidence interval 0.67–1.41, \( P=0.87 \)). It should be noted that the study by Hindricks et al. utilized an invasive monitoring system (implantable defibrillator with monitoring function) while the study by Koehler et al. utilized a non-invasive, daily monitoring system. Similarly, the impact of the mHealth interventions on cardiovascular mortality was mixed, with the invasive monitoring system resulting in a lower mortality rate for the intervention group (hazard ratio 0.37, 95% confidence interval 0.16–0.83, \( P=0.012 \)) while the non-invasive monitoring system showed no difference in cardiovascular mortality rates between the study groups (hazard ratio 0.86, 95% confidence interval 0.56–1.31, \( P=0.49 \)).
and non-invasive monitoring systems showed no significant difference in the number of HF-related hospitalizations between their study groups.\textsuperscript{22,19,25} Four of the six studies that examined the impact of their interventions on the length of hospital stay reported no significant differences between their study groups,\textsuperscript{22,24,19,25} while the remaining two studies reported significantly shorter lengths of stay for the intervention group compared to the control group.\textsuperscript{26,29}

The impact of mHealth interventions on the patients’ NYHA functional class was inconclusive. Three studies reported no significant differences in NYHA class composition between their study groups post-intervention.\textsuperscript{24,19,25} Two studies reported significant improvements in mean/median NYHA class for their intervention groups.\textsuperscript{29,27} In the study by Piotrowicz et al., the mean NYHA class for the intervention group post-intervention was 2.1 vs. 2.3 for the control group ($P=0.007$).\textsuperscript{27} Similarly, in the study by Scherr et al. (2009) the median NYHA class improved from 3 to 2 in the intervention group only ($P<0.001$).\textsuperscript{29} Finally, the quasi-experimental study by Scherr et al. (2006), reported an improvement in mean NYHA class from 2.3 to 1.8.\textsuperscript{28} However, the lack of a control group makes it difficult to ascertain whether this improvement is the result of the mHealth intervention or an unidentified confounder. Similarly, the same study\textsuperscript{28} reported an improvement in the mean LVEF of their study participants, while two other studies found no significant difference in the improvements in LVEF between their study groups.\textsuperscript{24,29}

Two of the five studies that measured quality of life used the Short Form (SF) 36 Health Survey,\textsuperscript{19,27} two studies used the Minnesota Living with Heart Failure Questionnaire (MLHFQ),\textsuperscript{22,24} and the remaining study used the SF-36 and the Kansas City Cardiomyopathy Questionnaire (KCCQ) to measure quality of life.\textsuperscript{26} Koehler et al. reported an improved score for the SF-36 physical functioning in the intervention group ($P=0.01$).\textsuperscript{19} Similarly, Seto et al. found a significant improvement in overall quality of life for their intervention group ($−8.9$ vs. $−0.5$, $P=0.05$).\textsuperscript{24} On the other hand, Hagglund et al. reported no significant difference in QOL between their study groups using the SF-36; however, they found a significant improvement in quality of life for their intervention group using the KCCQ.\textsuperscript{26} Piotrowicz et al. found no significant difference in the improvement in quality of life between the home-based cardiac rehabilitation group and the standard cardiac rehabilitation group ($−8.8$ vs. $−12.4$, $P=0.0001$).\textsuperscript{27} Finally, Zan et al. also found no significant difference in the pre- and post-intervention quality of life scores ($P=0.55$).\textsuperscript{22}

Finally, the impact of mHealth interventions on HF self-care was also mixed. Two\textsuperscript{23,24} of the three studies that measured self-care used the Self-Care of Heart Failure Index, while the remaining study\textsuperscript{26} used the European Heart Failure Self-Care Behavior Scale. One randomized controlled study reported no significant difference between their study groups,\textsuperscript{24} while another randomized controlled trial reported significant improvement in self-care in their intervention group.\textsuperscript{26} Similarly, a quasi-experimental study found significant improvements in self-care maintenance ($+28$ points, 95%CI $15–42$, $P=0.003$) and self-care management ($+30$ points, 95%CI $17–42$, $P=0.002$). However, the quasi-experimental study lacked a control group, which makes it difficult to conclusively associate the improvement in self-care with the mHealth intervention.
Discussion

Majority of the studies used mHealth technology to monitor the patients’ HF status. The most commonly used monitoring intervention consisted of a mobile communication device, a blood pressure measuring device, a weighing scale, and an ECG recorder. While most of the monitoring systems utilized a central monitoring center, how the monitoring was done and to what intensity greatly varied among the interventions. Two studies employed trained health professionals (nurses and physicians) to monitor the patients’ data while four studies used algorithms to generate alert messages in case the patients’ values were outside their predefined limits. Finally, most of the interventions were limited to monitoring the patients’ HF status and left the actual care of the patients (i.e. responding to the patients’ change in status) to their own physicians.

Similar to traditional telemonitoring interventions, the impact of an mHealth-based monitoring system on HF outcomes was inconclusive. A systematic review of multi-modal telemonitoring technologies also found inconsistent evidence on the impact of telemonitoring on HF outcomes (e.g. HF hospitalizations, length of stay, quality of life, self-care), which precluded a definitive conclusion of their positive impact. On the other hand, another systematic review focused on HF telemanagement concluded that the use of telehealth technologies in remotely managing HF patients had a positive impact on healthcare utilization, care costs, and quality of life. Taking these opposing review findings into consideration, one can infer that simply using these technologies to remotely monitor HF patients may not be as effective as using them to remotely manage the patients’ HF symptoms. Hence, mHealth technology could potentially see similar positive results if utilized beyond simple remote monitoring.

Furthermore, the inconclusive study findings could be attributed, in part, to the varying ranges of methodological rigor. For example, in the Koehler et al. study, the authors noted lack of power and the characteristics of their study sample (relatively stable with optimal treatment) as possible reasons for no intervention effect on all-cause and cardiovascular-related mortality rates. Therefore, they recommended that future studies should target HF sub-populations that would most likely benefit from this intervention. Hindricks et al., whose study sample was similar to that of Koehler et al. in terms of baseline HF status and medication regimen, found significantly lower mortality rates in their intervention group. However, it should be noted that Hindricks et al. used an invasive monitoring intervention (implantable defibrillator), which allowed for a much earlier detection of heart arrhythmias and worsening symptoms. Such finding suggests that monitoring HF symptoms once a day might not be sufficient to detect a worsening HF status, particularly among HF patients with higher acuity.

Another important aspect of interventions that needs to be taken into consideration is the response to the alerts generated by the systems. Among the three studies that provided data on the number of alerts generated and the subsequent response taken, a total number of 3278 alerts were generated; however, patients were contacted only 39% (range: 29% – 52%) of the time. Additionally, only one study reported their median reaction time (median: 1 day, interquartile range: 0–6). It is not known how many of these alerts were false.
positives. However, the low response rate to the alerts could be a potential factor as to why no significant differences were seen in HF outcomes between those that received the intervention and those in the control group.

Lastly, among the studies that reported participant adherence only one study achieved 100% adherence to their mHealth-based intervention.\textsuperscript{27} One study had over 20% of their intervention group fail to even start the intervention due to difficulties in operating their mobile phone’s Internet browser\textsuperscript{29} and another study reported a 60% attrition rate, the majority (57%) of which were lost due to technology issues.\textsuperscript{23} Among the studies that saw better adherence rates, one study still lost participants in their intervention group due to technical difficulties.\textsuperscript{24} The variability in participant adherence could be another potential contributor to the non-significant differences in HF outcomes between the study groups.

As with any systematic reviews, the quality of this review is dependent upon the quality of the included studies. Additionally, the small number of studies included could be seen as a limitation; however, this was unavoidable considering the novelty of mHealth interventions in HF management. Finally, the heterogeneity of the interventions and the measured outcomes precluded the performance of a meta-analysis; thus, limiting the rigor of this review. However, the critical assessment of the quality of the included studies using the Cochrane tool and the extensive, systematic search process conducted under the guidance of an expert medical librarian strengthened the quality of this review.

**Conclusion**

Majority of the mHealth-based HF interventions used mobile health technology to remotely monitor the patients’ HF status. The typical remote monitoring system included a mobile communication device, a blood pressure measuring device, a weighing scale, and an ECG recorder. The impact of the mHealth-based HF interventions on HF-related outcomes was mixed, highlighting the need for further research.

**Acknowledgments**

We would like to thank Ms. Stella Seal (medical librarian) for assisting with the database search.

**Funding:**

Maan Isabella Cajita and Kelly T. Gleason are supported by a predoctoral fellowship in Interdisciplinary Training in Cardiovascular Health Research (NIH/NINR T32 NR012704)

**References**


Implications for Practice and Future Research

Currently, the inconsistent impact of mHealth-based interventions on HF outcomes limits their utility in clinical practice. Findings from this systematic review suggest that further studies are critically needed to conclusively determine the impact of mHealth interventions on HF outcomes. Researchers should consider the limitations of the current studies (e.g. inadequate sample size, quasi-experimental design, use of older mobile phone models, etc.) when designing future studies. Additionally, researchers should involve representatives of their target population (i.e. people with HF) in the development stage in order to inform the design of their patient-device interface considering that a number of participants still had difficulties with the interventions despite the reported acceptable overall adherence to the current mHealth interventions. Furthermore, ease of use is just one factor that can affect adherence; other facilitators and barriers that influence adoption of mHealth interventions should also be examined. Lastly, studies should also consider performing cost-benefit analyses in order to determine whether mHealth HF interventions are cost-effective.
What’s New?

• Current mHealth-based interventions, which typically include a mobile communication device, a blood pressure measuring device, a weighing scale, and an ECG recorder, were utilized to remotely monitor HF patients.

• Overall, the impact of current mHealth interventions on HF outcomes, such as mortality, HF-related hospitalizations, length of hospital stay, NYHA functional class, LVEF, quality of life, and HF self-care, was inconclusive, which underscores the need for further research.
Figure 1.
Diagram of search and retrieval process. HF indicates heart failure.
### Figure 2.
Risk of Bias Assessment

<table>
<thead>
<tr>
<th>Study</th>
<th>Random sequence generation (selection bias)</th>
<th>Allocation concealment (selection bias)</th>
<th>Blinding of participants and personnel (performance bias)</th>
<th>Blinding of outcome assessment (detection bias)</th>
<th>Incomplete outcome data (attrition bias)</th>
<th>Selective reporting (reporting bias)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hagglund 2015</td>
<td>?</td>
<td>+</td>
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<tr>
<td>Scherr 2006</td>
<td>+</td>
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</tr>
</tbody>
</table>

- Low risk of bias
- Unclear risk of bias
- High risk of bias
Figure 3.
Risk of Bias Assessment Summary
## Table 1

### Study Characteristics

<table>
<thead>
<tr>
<th>First Author (Year) Country</th>
<th>Study Design</th>
<th>Study Duration</th>
<th>Sample (Size &amp; Description)</th>
<th>Intervention/ Control Group</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hagglund (2015) Sweden</td>
<td>RCT, multicenter</td>
<td>3 months</td>
<td>N = 72 (IG: 32, CG: 40) Mean: Age: IG 75y; CG 76y, Male: IG 21 (66%), CG 28 (70%), LVF: IG 34%; CG 38% NYHA: H: IG 12 (38%); CG 7 (18%); III: IG 20 (62%); CG 33 (82%)</td>
<td>IG: Self monitoring of weight and symptoms; HF information sheet; support access CG: HF information sheet; support access</td>
<td>• 23.8% attrition in the IG, which was not included in the analyses</td>
</tr>
<tr>
<td>Hindricks (2014) Australia, Israel, Europe</td>
<td>RCT, multicenter</td>
<td>12 months</td>
<td>N = 664 (IG: 333, CG: 331) Mean: Age: IG 65y; CG 66y, Male: IG 274 (82%), CG 262 (79%), LVF: IG 26%; CG 26% NYHA: II: IG 150 (45%); CG 135 (41%); III: IG 182 (55%); CG 196 (59%)</td>
<td>IG: Remote monitoring of heart rhythms CG: standard of care according to European guidelines</td>
<td>• No blinding to treatment allocation • Treatment after remote monitoring observations were not standardized nor were the clinical actions recorded</td>
</tr>
<tr>
<td>Koehler (2011) Koehler (2012) Germany</td>
<td>RCT, multicenter</td>
<td>24 months</td>
<td>N = 710 (IG: 354, CG: 356) Mean: Age: IG 67y; CG 67y, Male: IG 285 (81%), CG 292 (82%), LVF: IG 27%; CG 27% NYHA: II: IG 176 (50%); CG 180 (51%); III: IG 178 (50%); CG 176 (49%)</td>
<td>IG: Remote monitoring of ECG, blood pressure, and body weight CG: usual care according to current treatment guidelines for heart failure</td>
<td>• Low statistical power to detect clinically significant difference in mortality • No information were collected on the number of patients who were prescreened and who were not enrolled in the trial</td>
</tr>
<tr>
<td>Nundy (2013) USA</td>
<td>Quasi-experimental (no control group), single center</td>
<td>4 weeks</td>
<td>N = 15 enrolled → 6 completed study Mean: (N=15) Age: 50y Male: 9 (60%) Race: Black 14 (93%) LVF: 22%</td>
<td>Heart failure education and reminders via text messages</td>
<td>• Very small sample size with high attrition rate • No control group • Lack of CG precludes the determination of whether the improvements could be from clinic visits during the course of the intervention and/or simply improvement in health status</td>
</tr>
<tr>
<td>Piotrowicz (2010) Poland</td>
<td>RCT, single center</td>
<td>8 weeks</td>
<td>N = 152 (IG: 77, CG: 75) → 131 (IG: 75, CG: 56) Mean: (N=131)</td>
<td>IG: Home-based remotely monitored cardiac rehabilitation; patient education; psychological support</td>
<td>• Small sample size • Relative short duration of the study</td>
</tr>
<tr>
<td>First Author (Year)</td>
<td>Country</td>
<td>Study Design Study Duration</td>
<td>Sample (Size &amp; Description)</td>
<td>Intervention/ Control Group</td>
<td>Limitations</td>
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<tr>
<td>Cajita et al.</td>
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<tr>
<td>Scherr (2006)</td>
<td>Austria</td>
<td>Quasi-experimental (no comparison group), single center</td>
<td>90 days</td>
<td>IG: Age 56y, CG 61y Male: IG 64 (85%), CG 53 (95%) LVEF: IG 30%; CG 31% NYHA: II: IG 37 (49%), CG 31 (55%) III: IG 38 (51%), CG 25 (45%)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CG: standard cardiac rehabilitation; patient education; psychological support</td>
<td>• Lack of real-time ECG monitoring during remotely monitored rehabilitation</td>
</tr>
<tr>
<td>Scherr (2009)</td>
<td>Austria</td>
<td>RCT 6 months</td>
<td></td>
<td>IG: N = 120 (IG: 66, CG 54) → 78 (IG: 42, CG: 36) Mean: (N=108) Age: IG 65y, CG 67y Male: IG 40 (74%), CG 39 (72%) LVEF: IG 25%, CG 29% NYHA: II: IG 7 (13%), CG 7 (13%) III: IG 33 (61%), CG 37 (69%) IV: IG 14 (26%), CG 10 (19%)</td>
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<td></td>
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<td>CG: Remote automated monitoring of blood pressure and body weight</td>
<td>• Small sample size</td>
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<td></td>
<td>• Premature termination of randomization because of relevant technological issues</td>
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<td></td>
<td></td>
<td></td>
<td>• 12 “never beginners”</td>
</tr>
<tr>
<td>Seto (2012)</td>
<td>Canada</td>
<td>RCT, single center 6 months</td>
<td></td>
<td>IG: N= 100 (IG 50, CG 50) Only 82 returned pre-post questionnaires Mean: Age: IG 55y, CG 52y Male: IG 41 (82%), CG 38 (76%) LVEF: IG 27%, CG 27% NYHA: II: IG 21 (42%), CG 22 (44%) III: IG 6 (12%), CG 5 (10%) IV: IG 21 (42%), CG 21 (42%) IV: IG 2 (4%), CG 2 (4%)</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>IG: Remote automated monitoring of ECG, blood pressure, and heart rate; standard care</td>
<td>• Small sample size</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>CG: standard care (clinic visits once every 2 weeks to once every 3 to 6 months, heart failure education)</td>
<td>• Potential for recall bias and obsequiousness bias</td>
</tr>
<tr>
<td>Zan (2015)</td>
<td>USA</td>
<td>Quasi-experimental</td>
<td>90 days</td>
<td>IG: N = 21 (20 analyzed) Mean: Age: IG 53y; CG: 53y Male: IG 15 (71%), CG 14 (70%) LVEF: IG 35% NYHA: I: 5 (24%) II: 9 (43%) III: 7 (33%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>using a 1:1 matched control group by age, gender, race, and diagnosis, single center</td>
<td></td>
<td>IG: Remote monitoring of weight, blood pressure, and heart rate</td>
<td>• Small sample size</td>
</tr>
<tr>
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<td>• Potential selection bias due to purposeful sampling</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Predominantly married, white male sample</td>
</tr>
</tbody>
</table>

RCT- Randomized Control Trial, IG- Intervention Group, CG- Control Group, LVEF- Left Ventricular Ejection Fraction, NYHA – New York Heart Association
## Table 2

**Intervention Characteristics**

<table>
<thead>
<tr>
<th>First Author (Year)</th>
<th>Devices</th>
<th>Information Transfer</th>
<th>Central Monitoring Center</th>
<th>Monitoring Intensity</th>
<th>Monitoring Personnel</th>
<th>Patient Callback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hindricks (2014)</td>
<td>✓</td>
<td>Automatic</td>
<td>Yes</td>
<td>Not specified</td>
<td>Nurses, Physician</td>
<td>Optional</td>
</tr>
<tr>
<td>Koehler (2011, 2012)</td>
<td>✓ ✓ ✓</td>
<td>Automatic</td>
<td>Yes</td>
<td>24/7</td>
<td>Physician-led</td>
<td>Structured²</td>
</tr>
<tr>
<td>Nundy (2013)</td>
<td>✓</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Piotrowicz (2010)</td>
<td>✓ ✓</td>
<td>Automatic</td>
<td>Yes</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Structured²</td>
</tr>
<tr>
<td>Sato (2012)</td>
<td>✓ ✓ ✓</td>
<td>Automatic</td>
<td>Yes</td>
<td>Not specified</td>
<td>NA (Computer)</td>
<td>Optional²</td>
</tr>
<tr>
<td>Zan (2015)</td>
<td>✓ ✓ ✓</td>
<td>Automatic/Manual</td>
<td>Yes</td>
<td>“regular business hours”</td>
<td>Study staff</td>
<td>Structured²</td>
</tr>
</tbody>
</table>

* Wireless-enabled for automatic data transfer

1 Initiated by the study investigators

2 Initiated by the monitoring center, monthly and as needed per protocol; patient’s own physician also receives notifications from the monitoring center

3 Patients were given immediate feedback after transmission of ECG data to the monitoring center (i.e., permission to start exercise training session)

4 Patients’ physicians are notified thru text message/email if the patients’ values exceeded predefined limits. Physicians have the option to contact their patients.

5 Clinic cardiologists were emailed alerts if the patients’ values were outside target range; they then had the option to contact the patients if warranted.
<table>
<thead>
<tr>
<th>First Author (Year)</th>
<th>All-cause mortality</th>
<th>CV mortality</th>
<th>HF-related admissions</th>
<th>LOS</th>
<th>NYHA class</th>
<th>LVEF</th>
<th>QOL</th>
<th>Self-Care</th>
<th>Composite (CV mortality / HF admission)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hagglund (2015)</td>
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<td></td>
<td></td>
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<td></td>
<td>• Improved HF-specific QOL (P&lt; .05) and physical limitation (P=.06) in IG (based on KCCQ) • No difference between groups (based on SF-36) (physical component: P=.46, mental component: P=.99) Significant improvement in self-care (P&lt; .05)</td>
</tr>
<tr>
<td>Hindricks (2014)</td>
<td>Lower mortality rate in IG (hazard ratio .37, P=.012)</td>
<td>Lower mortality rate in IG (hazard ratio .37, P=.012)</td>
<td>No difference between groups (P=.38)</td>
<td>No difference between groups (P=.21)</td>
<td>No difference between groups (P=.43)</td>
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<tr>
<td>Koehler (2011, 2012)</td>
<td>No difference between groups (hazard ratio .97, P=.87)</td>
<td>No difference between groups (hazard ratio .86, P=.89)</td>
<td>No difference between groups (hazard ratio .84, P=.32)</td>
<td>No difference between groups (Cohen’s d=.08, P=.71)</td>
<td>No difference between groups (P&gt;.05)</td>
<td>Improved physical function in IG (P&lt;.05)</td>
<td></td>
<td></td>
<td>No difference between groups (P=.44)</td>
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<tr>
<td>Nundy (2013)</td>
<td></td>
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<td></td>
<td>• Significant improvement in self-care maintenance (Cohen’s d=.66, P=.005) • Significant improvement in self-care management (Cohen’s d=.92, P=.002) • No change in self-care confidence (Cohen’s d=.62, P=.11)</td>
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<tr>
<td>First Author (Year)</td>
<td>Outcomes</td>
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<tr>
<td>Piotrowicz (2010)</td>
<td>Greater improvement in NYHA class in IG ($P&lt;.007$)</td>
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<tr>
<td>Scherr (2006)</td>
<td>NYHA class (0 before ↔ after)</td>
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<td>I: 0 → 3</td>
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<td>II: 10 → 11</td>
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<td>III: 4 → 0</td>
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<tr>
<td>Scherr (2009)</td>
<td>Improved LVEF</td>
<td></td>
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<td>Median improved from III to II in the IG only ($P&lt;.001$)</td>
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<tr>
<td>Seto (2012)</td>
<td>No difference between groups ($P&gt;.05$)</td>
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<tr>
<td>Zan (2015)</td>
<td>No difference between pre- and post-intervention QOL scores in the IG</td>
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<td></td>
<td>(Cohen’s $d=-13$, $P=.55$)</td>
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</table>

CHAPTER 3
Intention to Use mHealth in Older Adults with Heart Failure

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Abstract

Background—mHealth, or the use of mobile technology in healthcare, is becoming increasingly common. In heart failure (HF), mHealth has been associated with improved self-management and quality of life. However, it is known that older adults continue to lag behind their younger counterparts when it comes to mobile technology adoption.

Objective—The primary aim of this study was to examine factors that influence intention to use mHealth among older adults with HF

Methods—An adapted Technology Acceptance Model was used to guide this cross-sectional, correlational study. Convenience sampling was used to participants from a large university hospital and online.

Results—A total of 129 older adults with HF participated in the study. Social influence ($\beta=0.17$, $P=0.010$), perceived ease of use ($\beta=0.16$, $P<0.001$), and perceived usefulness ($\beta=0.33$, $P<0.001$) were significantly associated with intention to use mHealth even after controlling for potential confounders (age, gender, race, education, income, and smartphone use). Perceived financial cost and eHealth literacy were not significantly associated with intention to use mHealth.

Conclusions—Researchers should consider using the participatory approach in developing their interventions in order to ensure that their mHealth-based interventions will not only address the patient’s HF self-management needs, but also be easy enough to use even for those who are less technology-savvy.

Keywords
mHealth; mobile technology; self-management; older adults; eHealth literacy

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Conflict of Interest: None
Background

Heart failure (HF) is especially prevalent in the older population. It is estimated that 11.8% of older adults have HF. Older adults also account for the majority of HF-related hospitalizations, which in turn accounts for 68% of the total cost of treating HF. Effective HF self-management is the key to reducing the enormous healthcare costs associated with treating HF. However, HF self-management can be complex, especially for older adults who usually have comorbid conditions. Hence, it is not surprising that nonadherence to recommended treatment plans is common among this population.

mHealth, or the use of mobile technology in health care, has the potential to revolutionize HF self-management. The ubiquity of mobile technology, such as mobile phones and tablet computers, has made it an ideal medium to deliver health interventions. In HF studies, mHealth-based interventions have used mobile devices as part of a larger monitoring system, usually in conjunction with a blood pressure measuring device and a weighing scale. Mobile devices have also been used to deliver HF-related educational messages. mHealth-based interventions have been associated with improved HF self-management, improved quality of life, and lower mortality. However, despite the promising impact of mHealth on HF outcomes, very little is known regarding individual characteristics and perceptions that influence its adoption, especially among older adults, who continue to lag behind their younger counterparts when it comes to technology adoption. Therefore, the primary aim of this study was to examine factors that influence intention to adopt mHealth among older people with HF. The secondary aims of this study were to explore current smartphone use in this population and to assess their intention to use mHealth if recommended by their primary healthcare provider.

Theoretical Framework

An adapted Technology Acceptance Model (TAM) was used to guide this study. The TAM is derived from the Theory of Reasoned Action and was first proposed by Dr. Fred Davis in 1985. The model posits that the strongest predictor of technology use is behavioral intention, which is in turn influenced by the individual’s perceived ease of use and perceived usefulness. Even in its most parsimonious version, the TAM has been shown to account for 30–40% of technology acceptance. In healthcare, TAM has been shown to explain from 30% to 70% of the variance in the acceptance of health technologies.

Perceived usefulness is conceptually defined as the degree to which the person with heart failure believes that using mHealth will enhance the management of his heart failure. In previous studies, perceived usefulness has been consistently shown to be significantly associated with intention to use technology and is thought to be the most important predictor of technology acceptance. Perceived ease of use is conceptually defined as the degree to which a person [with heart failure] believes that using a [mHealth] would be free of effort. Although not as consistent as perceived usefulness, perceived ease of use has also been shown to be associated with intention to use behavioral intention in several studies. Behavioral Intention is conceptually defined as the intention to use mHealth in the context of heart failure self-management. Being more proximal than the actual use of technology, it is often the outcome of choice for the majority of the TAM-guided studies. In longitudinal...
studies that actually measured actual use, behavioral intention has been shown to significantly predict actual use of technology.\textsuperscript{14}

In order to improve the predictive ability of the TAM, additional constructs were added to the model, namely: social influence, eHealth literacy, and perceived financial cost. Social influence is defined as a person’s perception that most people who are important to him/her think that he/she should perform the behavior in question,\textsuperscript{16} which in this case is technology adoption. Previous studies have shown that older adults are susceptible to the effects of social influence when it comes to technology acceptance.\textsuperscript{16} eHealth literacy is defined as “the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem”.\textsuperscript{17} Higher eHealth literacy has been found to be associated with higher perceived self-efficacy in using health-related mobile apps\textsuperscript{18} and with the adoption of a physician-rating mobile app.\textsuperscript{19} Perceived financial cost, defined as the extent to which the person believes that using mHealth will cost money, has been found to be significantly negatively correlated to behavioral intention.\textsuperscript{20}

\textbf{Methods}

\textbf{Study Design and Sample}

A cross-sectional, correlational design was used for this study. A convenience sample was recruited via two means: an “in-person” group from a large urban teaching hospital and an “online” group through Qualtrics\textsuperscript{\textregistered}. We opted to include an online sample in order to obtain a more geographically diverse sample. Potential “in-person” participants were identified through an electronic list of patients admitted with a history of heart failure, which was obtained daily from the hospital’s HF care coordinator. The patients on the list were then screened for eligibility through electronic chart review. Online participants were identified with the help of the Qualtrics\textsuperscript{\textregistered} project coordinator, who was given the inclusion and exclusion criteria for the study. Online sampling was limited to persons living in the United States.

Qualtrics is partnered with over 20 online panel providers. Panelists are often recruited to participate in research through online advertisements, or for groups that are hard-to-reach on the Internet, Qualtrics utilizes niche panels brought about through specialized recruitment campaigns (e.g. newspaper ads, inserts in product packaging, at trade events, or through direct mail). Hundreds of profiling attributes are collected to guarantee detailed knowledge of every potential respondent. Qualtrics panel partners randomly select respondents for surveys where respondents are highly likely to qualify. Each sample from the panel base is proportioned to the general population and then randomized before the survey is deployed. All sample partners redirect members by matching qualifying demographic information from their profiles to a specific survey. To ensure the quality of the data, Qualtrics will replace “quality check fails”, or respondents who straight-line through surveys, finish in less than 1/3 of the average survey completion length, or wrongly respond to attention checks (e.g. “This is an attention filter. Please select ‘Sometimes’ for this statement”). In order to prevent fraudulent respondents, panel providers utilize confirmation procedures such as TrueSample, Verity, SmartSample. USPS verification, and digital fingerprinting to verify
respondent address, demographic information, and email address. (Lincoln Bradshaw, Qualtrics Project Coordinator, email communication, January 22, 2016).

Participants were recruited if they had a history of HF and were 65 years or older. Current use of mHealth or smart phone technology was not an inclusion criterion because we wanted a range of experiences and perceptions. Potential “in-person” participants were excluded if they were unable to read/understand English, had a history of dementia or had cognitive impairment (Mini-Cog\textsuperscript{21,22} score \( \leq 2 \)), resided in a nursing home (prior to hospital admission), or were hospitalized for acute MIs and/or need emergent cardiac surgery, or advanced stage of HF (NYHA functional class IV – patient exhibits HF symptoms/shortness of breath even at rest per assigned nurse’s report). Intact cognitive functioning was assumed for the “online” group. Of the 168 who were eligible, 39 declined to participate in the study (23 were not interested, 12 did not feel well, and 4 had other reasons). There was no significant difference between those who participated in the study and those who declined to participate in terms of gender, race, educational attainment, income, and marital status. However, those who declined to participate were significantly older than the study participants (77 years vs. 71.3 years, \( P=0.001 \)). Figure 1 shows the participant recruitment flowchart.

**Procedures**

The university’s institutional review board approved this study. Before approaching the potential in-person participant, we obtained their permission to recruit them for the study through their assigned nurse. Once permission was obtained, they were approached by a trained research staff who briefly described the study. Written informed consent was then obtained from in-person participants, who screened negative for cognitive impairment, prior to the self- or staff-administered paper-based survey. The in-person group required approximately 45 minutes to complete the survey. The online participants were presented with an implied consent form at the beginning of the online survey. The online group required approximately 30 minutes to complete the survey. The in-person data collection was conducted between February and June 2016. The online surveys were collected between March and August 2016. Each participant was given $10 as an incentive for completing the survey.

**Survey**

An adapted TAM scale was used to measure the participants’ perceived social influence, ease of use, usefulness, and financial cost, and their intention to use mHealth.\textsuperscript{20,23} The adapted TAM scale had a total of 12 items (5 subscales) and used a 7-point Likert scale (see Appendix). Higher scores indicated higher perceived social influence, ease of use, usefulness, and financial cost, and higher intention to use mHealth. The internal consistency (Cronbach’s alpha) of the adapted TAM subscales for this sample is as follows: social influence (\( \alpha=0.91 \)), perceived ease of use (\( \alpha=0.78 \)), perceived usefulness (\( \alpha=0.92 \)), and behavioral intention (\( \alpha=0.82 \)). To give the participants a general sense of the types of mobile technology that could be used in HF self-management, pictures showing examples of mHealth (i.e. physical activity tracker wristband, heart rate tracker wristband + heart rate monitoring app, electronic blood pressure cuff that connects to an app) were included in the
survey. eHealth literacy was measured using eHEALS, which had 8 items and used a 5-point Likert scale. Higher scores indicated higher eHealth literacy. The internal consistency (Cronbach’s alpha) of eHEALS for this sample was 0.93. In addition, the participants were asked whose advice mattered the most to them when it comes to their health and whether they would use mHealth if their doctor or primary healthcare provider recommended it. Finally, demographic information (age, gender, race, educational attainment, income, and marital status) and information on the participant’s smartphone use were also collected using a questionnaire developed for the purpose of the study.

Data Analysis

Descriptive statistics were calculated for all study variables. Simple linear regression was used to test the relationship between the main study variables (eHealth literacy, social influence, perceived financial cost, perceived ease of use, and perceived usefulness) and intention to use mHealth. Hierarchical regression analysis was used to identify correlates of intention to use mHealth in the study sample and to determine the specific contributions of the main study variables in explaining intention to use mHealth above and beyond those of the covariates (age, gender, race, educational attainment, income, and current smartphone use). Stata 14 was used for all analyses. Level of significance was set at 0.05.

Results

Sample Characteristics

A total of 129 older adults with HF participated in the study. The mean age of the participants was 71.3 ± 4.6 years and the majority were male (73.6%). More than half (56.6%) identified themselves as White, followed by 22.5% who identified themselves as Black, and 20.9% as another race. The majority of the participants had at least some college education (79.1%), had an annual income of at least $50,000 (55.2%), and was married (64.3%). (Table 1)

Use of Smartphone and Intention to Use mHealth

Seventy-four (57.4%) of the participants used a smartphone, of which fifty-five (74.3%) reported using their smartphones daily. Among the non-smartphone users, thirty-six (27.9%) reported that they only need their phones to make calls; twenty (15.5%) indicated that smartphones were too complicated/difficult for them to use; and thirteen (10.1%) reported that smartphones were too expensive.

The majority of the participants (n=111, 86.1%) indicated that when it comes to their health their doctor’s/nurse practitioner’s advice mattered the most. Moreover, when asked whether they would use mHealth if their doctor (or primary healthcare provider) recommended it, 35 (27.1%) strongly agreed, 48 (37.2%) agreed, 27 (20.9%) somewhat agreed, 15 (11.6%) neither agreed nor disagreed, and the remaining participants either somewhat disagreed (1.6%) or disagreed (1.6%). Even among those who did not have a “high intention” to use mHealth (behavioral intention score <12), 55 (54.5%) agreed or strongly agreed that they would use mHealth if their doctor (or primary care provider) recommended it.
Correlates of Intention to use mHealth

Higher perceived ease of use ($\beta=0.16$, $P<0.001$) and higher perceived usefulness ($\beta=0.33$, $P<0.001$) were both associated with higher intention to use mHealth, even after controlling for the covariates. Perceived ease of use and perceived usefulness explained 9.5% and 13%, respectively, of the variability in intention to use mHealth. Perceived financial cost was associated with lower intention to use mHealth at the bivariate level but the association was no longer significant after adjusting for the covariates ($\beta=-0.04$, $P=0.345$). We also observed that social influence was associated with intention to use mHealth ($\beta=0.17$, $P=0.010$), even after controlling for the covariates; however, eHealth literacy was not ($\beta=-0.01$, $P=0.799$). (Table 2)

Discussion

Consistent with findings reported in the literature, we found that perceived usefulness was significantly associated with intention to adopt mHealth. In a recent systematic review, Chen and Chan reported that older adults will adopt new technology if it addressed an existing need or at least improved their daily living. Rather than focus on the technology’s high-tech features, older adults tend to value technology’s usefulness more and how it supports their activities and make tasks convenient. Perceived ease of use was also found to be associated with intention to adopt mHealth. This is also consistent with previous research. The functional and cognitive changes that come with aging, such as decreased dexterity, poorer vision, and diminished working memory, could make learning and using new technology more challenging for older adults. Hence, it only makes sense that the easier the new technology is to use; the more willing older adults will be to use it. Future researchers should consider using the participatory approach when designing their mHealth intervention. This would not only ensure that their intervention addresses the target user’s needs, but that its operability, or the amount of effort needed to use a device, matches the user’s abilities and capacity to learn the new technology. Health researchers could also benefit from collaborating with experts in human factors engineering (the study and practice of designing equipment and environments to accommodate human users) when developing mHealth-based interventions.

While it is to be expected that intrinsic factors, such as their perceptions on the usefulness and ease of use of the technology, will play a significant role in whether older adults intend to adopt mobile technology to help manage their HF, it is worth noting the significant impact of social influence, particularly that of their primary healthcare provider. This significant association could be a reflection of the trust that older adults tend to put on their physicians and on nurses. Future research should explore the role of primary healthcare providers in promoting the adoption of mHealth-based HF interventions.

Unlike the findings from previous studies, we found that eHealth literacy and perceived financial cost were not significantly associated with intention to adopt mHealth. In their study of mobile physician-rating apps, Bidmon et al. found that eHealth literacy was associated with adoption of the mobile app. However, their study sample was considerably younger and had higher average eHealth literacy. Unlike the findings of Tung et al., perceived financial cost was not associated with intention to use mHealth. A possible...
explanation for the lack of association could be the higher annual income reported by this study’s sample, which was significantly higher than the $35,611 national median income previously reported for this age group. The cost of mobile technology might not factor into someone’s decision to adopt mHealth if they can easily afford it. Another potential explanation could be the higher rate of smartphone ownership among this study’s participants in comparison to the national average (57% vs. 27%). Since they already have a mobile device; hence, the cost of mobile technology would not really affect their decision to use mobile technology to help manage their HF.

This study has several limitations. The cross-sectional design of the study precludes causal inferences. While behavioral intention has been previously shown to predict actual technology adoption, future research should consider using a longitudinal design. Additionally, the majority of the study’s participants (94%) were “younger” older adults (65 – 79 years); hence, our findings may not be generalizable to the oldest members of the HF population. Similarly, the study sample tended to include those with higher education and income than the average older adult American, which further limits the generalizability of the study findings. In addition, given that the use of mobile technology in HF self-management is still in the research phase, we assumed that the participants have not yet used mHealth for HF self-management and only surveyed the participants regarding their use of smartphones.

Conclusions

In order to promote the adoption of mHealth-based HF interventions among the older HF population, it is essential that researchers use a participatory approach in the development phase of their interventions in order to ensure that their mHealth-based interventions will not only address the end user- or older adult’s-most pressing HF self-management needs, but also be easy enough to use even for the less technology-savvy. Lastly, implementation of research-tested mHealth interventions could benefit from the endorsement of primary healthcare providers in order to promote their adoption, especially among older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding:

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We would like to acknowledge the contributions made by Prof. Joseph Gallo, MD and Prof. Debra Roter, DrPH in the design of this study.

References


What’s New?

- Among older adults with HF, their perceptions of mHealth’s ease of use and usefulness influenced their intention to adopt it. Researchers looking to use mobile technology to deliver HF interventions should consult their target population when designing their interventions in order to ensure that it will address their needs and that it would be easy enough to use even for those who are not technology-savvy.

- Social influence, particularly from one’s primary healthcare provider, influenced the older adult’s intention to adopt mHealth. This suggests that implementation of research-tested mHealth interventions could benefit from the endorsement of primary healthcare providers.
Figure 1.
Participant recruitment flowchart (Abbreviation: HF – heart failure)
Table 1

Participant Characteristics

<table>
<thead>
<tr>
<th>Variable, N (%)</th>
<th>Overall (N=129)</th>
<th>In-Person (n=29)</th>
<th>Online (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong>, mean ± SD (range)</td>
<td>71.3 ± 4.6y (65–86)</td>
<td>71.5 ± 5.1y(66–86)</td>
<td>71.2 ± 4.4y(65–83)</td>
</tr>
<tr>
<td>Gender*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>95 (73.6)</td>
<td>17 (58.6)</td>
<td>78 (78.0)</td>
</tr>
<tr>
<td>Female</td>
<td>34 (26.4)</td>
<td>12 (41.4)</td>
<td>22 (22.0)</td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>73 (56.6)</td>
<td>11 (37.9)</td>
<td>62 (62.0)</td>
</tr>
<tr>
<td>Black</td>
<td>29 (22.5)</td>
<td>16 (55.2)</td>
<td>13 (13.0)</td>
</tr>
<tr>
<td>Other</td>
<td>27 (20.9)</td>
<td>2 (6.9)</td>
<td>25 (25.0)</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school grad or less</td>
<td>27 (20.9)</td>
<td>15 (51.7)</td>
<td>12 (12.0)</td>
</tr>
<tr>
<td>College grad or less</td>
<td>69 (53.5)</td>
<td>9 (31.0)</td>
<td>60 (60.0)</td>
</tr>
<tr>
<td>Professional/Grad school</td>
<td>33 (25.6)</td>
<td>5 (17.3)</td>
<td>28 (28.0)</td>
</tr>
<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;$15,000</td>
<td>10 (8.0)</td>
<td>8 (32.0)</td>
<td>2 (2.0)</td>
</tr>
<tr>
<td>$15,000–$50,000</td>
<td>46 (36.8)</td>
<td>5 (20.0)</td>
<td>41 (41.0)</td>
</tr>
<tr>
<td>$50,001–$100,000</td>
<td>46 (36.8)</td>
<td>7 (28.0)</td>
<td>39 (39.0)</td>
</tr>
<tr>
<td>&gt; $100,000</td>
<td>23 (18.4)</td>
<td>5 (20.0)</td>
<td>18 (18.0)</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>83 (64.3)</td>
<td>13 (44.8)</td>
<td>70 (70.0)</td>
</tr>
<tr>
<td>Not Married</td>
<td>46 (35.7)</td>
<td>16 (55.2)</td>
<td>20 (30.0)</td>
</tr>
<tr>
<td><strong>Smartphone users</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smartphone users*</td>
<td>74 (57.4)</td>
<td>12 (41.4)</td>
<td>62 (62.0)</td>
</tr>
<tr>
<td><strong>eHealth Literacy</strong>, mean ± SD (range)</td>
<td>27.3 ± 6.4 (8–40)</td>
<td>22.1 ± 7.6 (8–37)</td>
<td>28.7 ± 5.1 (13–40)</td>
</tr>
</tbody>
</table>

Note: Difference between the in-person and online groups were significant at *P<0.05, **P<0.001
Table 2

Correlates of Intention to Use mHealth

<table>
<thead>
<tr>
<th>Variable</th>
<th>β   (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Block 1: R²=0.223, P=&lt;0.001</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.05 (−0.01–0.11)</td>
<td>0.089</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>Reference group</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>−0.39 (−1.06–0.27)</td>
</tr>
<tr>
<td>Race</td>
<td>White</td>
<td>Reference group</td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td>0.47 (−0.25–1.18)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>−0.68 (−1.32–0.03)</td>
</tr>
<tr>
<td>Education</td>
<td>High school grad or less</td>
<td>Reference group</td>
</tr>
<tr>
<td></td>
<td>College grad or less</td>
<td>−0.05 (−0.82–0.71)</td>
</tr>
<tr>
<td></td>
<td>Professional/Grad school</td>
<td>−0.001 (−0.88–0.87)</td>
</tr>
<tr>
<td>Income</td>
<td>$35K or less</td>
<td>Reference group</td>
</tr>
<tr>
<td></td>
<td>&gt; $35K</td>
<td>−0.28 (−0.96–0.40)</td>
</tr>
<tr>
<td>Smartphone use</td>
<td>Non-user</td>
<td>Reference group</td>
</tr>
<tr>
<td></td>
<td>User</td>
<td>0.77 (0.21–1.34)</td>
</tr>
<tr>
<td><strong>Block 2: change in R²&lt;0.001, P=0.829</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eHealth literacy</td>
<td>−0.01 (−0.05–0.04)</td>
<td>0.799</td>
</tr>
<tr>
<td><strong>Block 3: change in R²=0.281, P=0.001</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Influence</td>
<td>0.17 (0.04–0.30)</td>
<td>0.010</td>
</tr>
<tr>
<td><strong>Block 4: change in R²=0.017, P=0.049</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived financial cost</td>
<td>−0.04 (−0.14–0.05)</td>
<td>0.345</td>
</tr>
<tr>
<td><strong>Block 5: change in R²=0.095, P=0.001</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived ease of use</td>
<td>0.16 (0.07–0.24)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Block 6: change in R²=0.130, P=0.001</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived usefulness</td>
<td>0.33 (0.24–0.41)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Regression coefficients presented are from the full model
Facilitators and Barriers of mHealth Adoption in Older Adults with Heart Failure

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Abstract

**Purpose of the Study:** The aim of this qualitative study was to explore the perceptions of older adults with heart failure (HF) regarding the use of mobile technology in the management of their HF (mHealth), in order to identify potential facilitators and barriers to mHealth adoption.

**Design and Methods:** Semistructured interviews were used to collect the data. Transcripts were analyzed using qualitative content analysis.

**Results:** The findings indicated that older adults do not solely base their intention to use mHealth on perceived ease of use and perceived usefulness, as outlined in the Technology Acceptance Model. The following themes emerged from the content analysis: (facilitators) previous experience with mobile technology, willingness to learn mHealth, ease of use, presence of useful features (e.g. large display, audio function, automatic data transfer), adequate training, free equipment, and doctor’s recommendation; (barriers) lack of knowledge regarding how to use mHealth, decreased sensory perception (i.e. poor vision and/or hearing), lack of need for technology, poorly-designed interface, cost of technology, and limited/fixed income.

**Implications:** Overall, the findings suggest that older adults are willing to use mobile health technology albeit not without reservations. Future researchers looking to implement mHealth-based interventions should address the person-related, technology-related, and contextual barriers, at the same time capitalize on the influence of potential facilitators, such as the doctor’s recommendation, to promote mHealth adoption.

**Keywords:** mobile health, mobile technology, gerontechnology, heart failure, self-management
Introduction

Heart failure (HF) is prevalent in the older population. It is estimated that 80% of the 5.7 million people with HF are aged 65 years or older (Vigen, Maddox, & Allen, 2012). Effective HF self-management is key to preventing hospitalizations, which is very common in the HF population (Hall, Levant, & Defrances, 2012). However, HF self-management can be complex; it involves symptom monitoring, medication management, dietary modifications, and activity adjustments to achieve symptom control (Bui & Fonarow, 2012; Gardetto, 2011). In addition, older adults often have other comorbid conditions, which adds to the complexity of their treatment regimen (Mastromarino et al., 2014; Riegel, Lee, & Dickson, 2011); hence, nonadherence to the recommended treatment regimen is quite common in this population (Moser & Watkins, 2008). One promising solution is the use of mobile technology in HF self-management.

While a consensus on how to define mHealth has yet to be reached, mHealth is commonly defined as the use of mobile and wireless devices, such as mobile phones, tablet computers, patient monitoring devices, and mobile applications (apps), to support the achievement of health objectives (United States Agency for International Development, 2016). The popularity and the increasing capabilities of these mobile devices have made them an ideal medium to deliver health interventions. Current uses of mobile technology in chronic disease management interventions include: text-based appointment reminders (Gurol-Urganci, de Jongh, Vodopivec-Jamsek, Atun, & Car, 2013; Nundy et al., 2013), medication reminders (Nundy et al., 2013), motivational health messages (Arora, Peters, Agy, & Menchine, 2012; Nundy et al., 2013), electronic medication tracking (Brath et al., 2013), and remote symptom monitoring (Evans et al.,
In HF, mHealth-based interventions have been associated with improved HF self-management (Hägglund et al., 2015; Nundy et al., 2013), improved quality of life (Hägglund et al., 2015; Seto et al., 2012), and lower mortality (Hindricks et al., 2014). Despite the potential of mHealth to revolutionize HF self-management, its efficacy ultimately lies on its adoption and sustained use by its intended user. And while the use of mobile devices is increasing among the older population, older adults continue to lag behind their younger counterparts when it comes to technology adoption (Pew Research Center, 2014). Therefore, it is essential to explore the perceptions older adults towards mHealth in order to identify potential facilitators and barriers to its adoption.

Although there has been a steady increase in the number of studies exploring technology adoption/acceptance among older adults (Chen & Chan, 2011; Peek et al., 2014), few have focused on mobile technologies (Conci, Pianesi, & Zancanaro, 2009; Ma, Chan, & Chen, 2016; Tsai, Shillair, Cotten, Winstead, & Yost, 2015) and even fewer have explored the acceptability of using mobile technology for health-related purposes (McMahon et al., 2016; Preusse, Mitzner, Fausset, & Rogers, 2016). Furthermore, none of the studies examined older adults’ perceptions of mHealth for HF or chronic disease self-management. A better understanding of the facilitators and barriers that could influence older adults’ intention to adopt mHealth for HF self-management could guide the development and implementation of future mHealth-based HF interventions. Hence, the purpose of this study was to explore older adults’ perceptions of using of mobile technology to manage their HF, in order to identify potential facilitators and barriers to mHealth adoption.
Methods

Design and Conceptual Framework

An adapted Technology Acceptance Model (TAM) was used to guide this sequential mixed-methods study. The TAM posits that the strongest predictor of technology use is behavioral intention, which, in turn, is influenced by the individual’s perceptions of the technology’s usefulness and ease of use (Holden & Karsh, 2010). Over the years, there have been numerous iterations of the TAM; however, the core constructs have remained the same (i.e. perceived ease of use, perceived usefulness, and behavioral intention) (Holden & Karsh, 2010). In health-related studies, the TAM has been shown to explain from 30% to 70% of the variability in the acceptance of health technologies (Holden & Karsh, 2010). In order to further explore the perceptions of older adults regarding mHealth and identify additional facilitators and barriers to mHealth adoption beyond what is outlined in the TAM qualitative interviews were conducted to supplement the findings of the quantitative study. This paper will focus on the findings from the qualitative phase of the study.

Setting and Sample

Participants for the qualitative phase were purposively sampled from the larger quantitative study to ensure variation in terms of intention to use mHealth (score on the TAM-Intention to Use subscale – high/moderate/low intention to use mHealth), smartphone ownership, and demographic characteristics (gender, race, educational attainment, and income). The participants were recruited from a large urban teaching hospital. Patients were eligible to participate if they were 65 years or older, had a history
of HF, able to communicate in English, cognitively intact [screened using the Mini-Cog (Patel, Parikh, Howell, Hsich, & Gorodeski, 2014)], and did not reside in a nursing home prior to hospital admission.

**Data Collection**

After informed consent was obtained, a trained research assistant (KWL and SY) conducted individual in-depth interviews with the participants in their private hospital rooms. The semistructured interviews were designed to elicit the participants’ perceptions of mobile technology and in its potential use in managing HF. The interview guides were tailored according to the participants’ response to the quantitative survey (e.g. *You indicated that you would consider using mobile technology to help manage your HF, could you tell more about that?* *You indicated that mobile technologies are too difficult to use, what is it about them that makes them difficult to use?*). Besides questions that were aimed to elaborate on their survey responses, participants were also asked about their perceptions on potential facilitators and barriers to mHealth adoption (e.g. *What would you say would make older people start using mobile technology to help manage their health? What do you think keep older people from using mobile technology?*). In addition, the participants were shown a video of an mHealth monitoring system and a mobile app, and were then asked follow-up questions (e.g. *Do you think this technology/app would be easy to use, what makes it easy/hard to use? Do you think this technology/app would be useful, what makes it useful/not useful?*). The video showed a typical monitoring system composed of a weighing scale, blood pressure cuff, and pulse oximeter that were wirelessly connected to a mobile device. The video was selected since it presented how the mHealth system worked in a straightforward, objective manner (i.e.
non-advertising manner) to avoid influencing the participants’ perceptions. Finally, with
the same tablet that was used to show the mHealth video, the participants were presented
with a mobile app that is designed to track dietary salt intake. The app was chosen
because it was free to download and its features were typical for a “tracker/counter” app
(thus providing a good starting point for discussion). In addition, the purpose of the app
(dietary salt intake monitoring) is relevant to heart failure self-management. After a
demonstration by the research assistant, the participants were then asked to interact with
the app whilst sharing their thoughts. The think-aloud technique is extensively used in the
field of usability testing. This technique not only allows the interviewer to elicit the
user’s thoughts and preferences, but also the reasoning behind them. Clarification and
elaboration probes were used all throughout the interviews as needed. Interviews lasted
from 25 to 45 minutes and were conducted between February and April 2016. The
interviews were audio recorded and transcribed verbatim. Transcriptions were routinely
reviewed to assess for data saturation; data collection stopped when no new data emerged
from the interviews. The participants received an additional $15 for participating in the
interview (participants were given $10 for completing the survey). This study was
approved by the university’s Institutional Review Board.

Data Analysis

The transcripts were reviewed to verify their accuracy prior to coding. The
transcripts were analyzed using qualitative content analysis following the core steps
outlined by Cho and Lee (2014). The analysis process included the following steps: 1) each transcript was read in its entirety to gain a general sense of the content; 2) phrases or
passages were then coded either as a facilitator (defined as any attribute, condition, or
occurrence that aids or facilitates the adoption on mHealth) or a barrier (defined as any attribute, condition, or occurrence that hinders or prevents the adoption of mHealth); 3) coded phrases or passages were then categorized into ‘person-related factors’ (i.e. factors inherent to the individual), ‘technology-related factors’ (i.e. characteristics or features related to mobile technology), and ‘contextual factors’ (i.e. all other factors that were not person- or technology-related); and 4) each was then examined to identify themes. The first three steps of the analysis process were performed independently by two trained research assistants (KWL and SY) and then discussed together with the first author. Steps 1-3 followed the deductive approach, wherein predetermined codes (facilitator/barrier) were used and then classified using a predetermined organizational matrix. The last step of the analysis process followed the inductive approach. The first author developed the preliminary themes, which were then discussed and revised by the authors together. Representative quotes are presented to increase the credibility (truth value) of the study findings (Cho & Lee, 2014). The use of purposive maximum variation sampling was intended to help increase the transferability (applicability) of the study findings, while multiple coders were employed to increase reliability (Creswell & Plano Clark, 2011). Finally, an audit trail was maintained to increase the dependability (consistency) of the findings (Cho & Lee, 2014).

**Results**

**Sample Description**

Half of the 10 participants expressed intention to use mHealth while the rest either had no intention to use mHealth (n=2) or were uncertain (n=3). Six of the participants were smartphone owners. The participants ranged in age from 66 to 83 years old; seven
were male; half identified themselves as White and the other half as Black; and five were married. As far as educational attainment, two had a Master’s degree, two had a Bachelor’s degree, two attended college but did not graduate, 3 were high school graduates, and one attended primary school but did not finish. Three participants had an annual household income of <$15K, two had $35-50K, one had $50-70K, three had $75-100K, and one had annual household income >$100K. (Table 1)

<table>
<thead>
<tr>
<th>Participant</th>
<th>Intention to Use mHealth</th>
<th>Gender</th>
<th>Race</th>
<th>Education</th>
<th>Income</th>
<th>Marital Status</th>
<th>Smartphone User</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>M</td>
<td>Black</td>
<td>Some college, &gt;1year</td>
<td>$50-75K</td>
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<td>Yes</td>
</tr>
<tr>
<td>2</td>
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<td>White</td>
<td>HS grad</td>
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<td>Single</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
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<td>White</td>
<td>Master’s</td>
<td>$35-50K</td>
<td>Divorced/Separated</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
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<td>M</td>
<td>Black</td>
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<td>Married</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
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<td>Black</td>
<td>Bachelor’s</td>
<td>$75-100K</td>
<td>Married</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Low</td>
<td>F</td>
<td>White</td>
<td>Master’s</td>
<td>&gt;$100K</td>
<td>Single</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
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<td>Bachelor’s</td>
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<td>No</td>
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<tr>
<td>8</td>
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<td>Black</td>
<td>Some college, &lt;1year</td>
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<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>High</td>
<td>M</td>
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<td>HS grad</td>
<td>$75-100K</td>
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<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Moderate</td>
<td>F</td>
<td>Black</td>
<td>HS grad</td>
<td>&lt;$15K</td>
<td>Divorced/Separated</td>
<td>No</td>
</tr>
</tbody>
</table>

**Person-related Factors**

*Lack of knowledge*

The most frequently mentioned barrier was a lack of knowledge on how to use mobile technology. Whether it was the participant’s own lack of knowledge or what they perceived was the lack of knowledge among older adults in general, the participants
believed that not knowing how to operate mobile devices kept older adults from using such technology.

“I think they’re good, but I just don’t know how to use, to work it. I just don’t have the knowledge on how to work it.” – Participant 10

“I think the first thing is the lack of technical know-how is one the barriers.” – Participant 5

Furthermore, the participants shared that this lack of knowledge could sometimes lead to fear of doing something wrong and potentially ruining the device. As a result, older adults tend hesitate using mobile technology.

“Well, for one thing, when you use a technology, you got to know what that feature is used for. And if you don’t know what that feature is used for then if you touch it and it goes the wrong way, then you’re in trouble.” – Participant 8

“Uh, probably fear of not being able to do it and the fact that these technologies were not available (clearing throat) when an older person was younger. They have to learn something new, and I think it scares them. Like they’re gonna, you know, like I remember when we started getting computers, older people would be afraid they’d do something to ruin the computer.” – Participant 3

Similarly, the participants shared that as they got older they found it more difficult to keep pace with all the new technology, which led some to feel reluctant to even try to use mobile technology.
“As I get older and more technology comes out, you know, you sort of start falling behind. I try to keep up but...” – Participant 3

“You know, my feeling is, I mean like, there were things when I was younger that I would do, but now, as I age I keep doubting myself and I wouldn’t even try it now.” – Participant 7

*Decreased sensory perception*

Another potential barrier to mHealth adoption is a decline in sensory perception (i.e. sight, hearing). A decrease in visual acuity would make interacting with the mobile device interface difficult for older users. Similarly, older adults with hearing impairment would find it hard to hear audio prompts or alerts.

“Once you start going to the older generation, there are the people who are likely to have these heart problems, also be visually impaired and hearing impaired, if you do not have the two systems it could be a barrier.”

– Participant 5

*Lack of need for technology*

Not as frequently mentioned as the other barriers, however equally noteworthy, is the lack of need for mobile technology. As one participant shared, being able to manage one’s heart failure without the aid of mobile technology offers little reason to start using it.

“Many of these things I do already and I don’t see the necessity for having to use technology to get there. I mean, I record my weight everyday; I record my blood pressure using a pencil and paper. And I, uh, I record my
blood pressure when I go to the doctor. So it’s all written, not computerized.” – Participant 6

Previous experience with mobile technology

On the other hand, having previous experience with mobile technology was mentioned as a facilitator of mHealth use. Participants whose previous occupation involved working closely with mobile technology expressed more confidence in learning how to use it for health-related purposes.

“You know I worked for ABC communications*, so whenever the smartphone technology came out, we’re the first ones to get it.”

[Interviewer: So would you say it is easy for you to learn how to use mobile health technology?] “Any kind of new technology.” – Participant 1 (*changed to protect the participant’s anonymity)

Similarly, having previous experience with mHealth through one’s work also facilitated one’s intention to use mobile technology to manage their health.

“Uh, well I haven’t been doing any volunteer nurse practitioner work, but I’ve used uh, a couple medical apps, just to look up medication, side effects, or treatment modalities for patients that I’d be taking care of”

[Interviewer: Would you consider using a health-related app if it would help you to manage your health?] “Yes” – Participant 3

Willingness to learn

For participants without previous experience with mobile technology, having the willingness to learn how to use mobile devices can facilitate mHealth adoption.
“Yeah, I’d definitely be willing to learn, you know, even at my age, I would still like to learn” – Participant 10

**Technology-related Factors**

*Overall ease of use*

Most of the participants expressed that they would be more likely to adopt mHealth if it was easy to use. For the participants, ease of use meant that it only required a few simple steps to operate the device.

“I like it, it’s easy (laughs). It doesn’t have many steps to it” – Participant 3, in reference to the mHealth monitoring system

“You don’t have to do a lot, all you got to do is read it [the display]” – Participant 9, in reference to the mobile app

*Presence of useful features*

The participants also pointed out several features of the mHealth monitoring system that they found useful. In particular, they appreciated the large display, audio feedback, and automatic data transfer.

“Well, you got a nice large display, and you got audible functionality” – Participant 1

“The oral, uh, reading is helpful” – Participant 3

“Well the transference of the, the results to, to the, uh central unit, and, and put in the memory is one that seems to me the most useful” – Participant 7

Another feature of the mHealth monitoring system than the participants found useful was the instant feedback. As one participant pointed out that the instant feedback from the
mHealth device can be a form of encouragement or motivation for the person to better manage their HF.

“Well, I think the feedback is more useful. If the result is known to the person, I think that feature, the instant feedback, interactive, this is what it is today, therefore tomorrow I need to improve or something, that feedback to the patient is what you want to achieve results” – Participant 5

When asked if they could improve the design of the mHealth device, one participant suggested a reminder feature.

“Something to remind me so that I won’t forget to take my medicine, something that goes ‘beep beep’ and lights up, it’s got to light up because I can’t hear” – Participant 8

*Poorly designed interface*

Given their decreased visual acuity, the participants found the size of icons and texts on the mobile app hard to read and suggested that their size be increased or to at least increase the contrast between the text and the background.

“These little icons are too small” – Participant 1

“Make the font a little bigger or if you don’t make it bigger at least make it more noticeable, like dark, darker” – Participant 10

*Cost of technology*

Besides the hard-to-see interface, the only other technology-related barrier that was mentioned was the perceived high cost of new technology. Participants expressed that, while they were willing to use mHealth, they believed that it would cost too much, and that they would rather wait for the price to drop.
“I might want to have one but it’s not in my price range” – Participant 4

“When new technology comes out it’s expensive. Yeah because like I’ve watched automatic blood pressure cuffs really come down in price. So I think initially it might be too expensive for me” – Participant 3

Contextual Factors

Adequate training

In relation to the expressed lack of knowledge about mobile technology, majority of the participants stated that if they were provided with adequate training they would be willing to use mobile technology to help manage their HF.

“Teach them how to use it, that would be the main thing. Because what sense in purchasing it and you don’t know how to use it? At least give them education on the first time or I say at least 4 or 5 times give them, you know, give them education on how to use it” – Participant 10

“If you provide the training then I think people would be more apt to using the technology” – Participant 5

Doctor’s recommendation

Similarly, the participants expressed that they would be willing to use mHealth if their doctor recommended it. The trust that patients have on their doctor’s advice could facilitate mHealth adoption.

“If my doctor recommended something like this, and my doctor, mind you, is very very very concerned with her patients, and, you know, anybody that you think the world of is not going to lead you wrong, you
know, and that’s the reason why I would consider using one if my doctor recommended it” – Participant 8

Free equipment

In relation to the perceived financial cost of mHealth, participants expressed their willingness to use mHealth if the equipment was provided to them for free.

“I would consider using this kind of technology only if it were given to me” – Participant 6 “Well, I tell you like this, if they gonna pay for me to use one, then I will use one for my health, because I feel that if they just was confident in this machine and they is willing to give it to me and take care of the bill and everything of it, I’m willing to try” – Participant 8

Limited/fixed income

Finally, older adults see the perceived high cost of mHealth technology as a deterrent given that most of them are retired and have fixed incomes. Some of the participants considered the cost of acquiring an mHealth device as an additional expense that would further stretch their already limited budget.

“Because most of the people who would be in this situation have had problems normally at their age when they are on a fixed income or retirement or something. So it depends, unless a person is really wealthy. Because it used to be paycheck to paycheck, and now you're in retirement and now you have to take care of additional medical bills, this extra addition of expenditure could be a factor” – Participant 5

“It’s going to come down to cost, like I said, I’m on social security so that’s a big factor. It would depend upon the amount of money really, if I
can afford it or not is the key question. I mean, I would certainly be willing to buy all of these things if I could afford them” – Participant 7

Discussion

The results of this study indicated that older adults do not solely base their intention to use mHealth on perceived ease of use and perceived usefulness, as outlined in the Technology Acceptance Model. The qualitative findings provided additional insight on what older adults perceived as facilitators and barriers to mHealth adoption. It is worth noting that while these facilitators and barriers were organized into three categories (person-related, technology-related, contextual), they were related to each other in one way or another (e.g. a contextual facilitator might address a person-related barrier, a person-related barrier could be addressed by a technology-related facilitator). The following themes emerged under the category person-related factors: lack of knowledge, decreased sensory perception, and lack of need for technology (barriers), previous experience with mobile technology and willingness to learn (facilitators). Under technology-related factors, the following themes were identified: poorly designed interface and cost of technology (barriers), overall ease of use and the presence of useful features (facilitators). Lastly, under contextual factors, the following themes emerged: limited/fixed income (barrier), adequate training, doctor’s recommendation, and free equipment (facilitators).

The most frequently mentioned barrier to mHealth adoption was the lack of knowledge on how to use mobile technology to help manage their HF. This is in line with the findings of Mercer et al. (2016) who found that older adults had low self-efficacy when it comes to learning how to use mobile health technology and viewed it as
something that was designed for the younger generation. This is to be expected given that today’s older generation did not have these technologies when they were growing up and considering that the use of mobile technology for health-related purposes is fairly recent. In particular, mHealth use in HF self-management is still in its infancy (Cajita, Gleason, & Han, 2016), and is still not considered routine care (Yancy et al., 2013). Despite this lack of knowledge, older adults expressed a willingness to learn how to use mHealth.

A contextual facilitator that could address older adults’ lack of knowledge is the provision of adequate training and support in the use of mHealth. Adequate technical support was also found to be a facilitator of telehealth use in study by Cimperman, Brenčić, Trkman, & de Leonni Stanonik (2013). Special consideration should be given to tailor the training process according to the older adult’s ability to learn the new technology. As one participant pointed out, a one-time training session might not be sufficient. This is important given that dissatisfaction with the technical support provided has been reported to play a role in older adults discontinuing to use technology (Peek et al., 2016). It is widely known that working memory declines as one ages (Chen & Chan, 2011). While this decline in cognitive ability does not prevent the acquisition of new knowledge (e.g. learning how to operate mobile technology), it does mean that older adults will require more time to learn how to use mobile health technology. Future researchers looking to implement mHealth-based HF self-management interventions should consider tailoring the training process to the older user’s ability to learn the new technology. Refresher training sessions should be provided, at least in the beginning stages of the intervention implementation, until the older adult user has sufficiently
mastered how to operate the device. In addition, technical support should be readily available to assist the older adult user in troubleshooting problems that could crop up.

Mobile health technology should be designed so that it is easy to use and only requires a few simple steps to operate in order to facilitate the older adult’s learning process and promote mHealth adoption. The importance of ease of use was also emphasized in a study by Tsai et al. (2015). The study found that older adults preferred tablets to regular computers since it only required a few swipes of the finger instead of having to learn a series of steps to accomplish the same task. Another important factor to consider when designing an mHealth device is the physical limitations that older adults have. The design should accommodate for the age-related vision and hearing impairments that are common among older adults. In a study by Kim & Sundar (2014), a larger screen size was found to be associated with higher technology adoption. Hence, tablets, which have larger screens compared to mobile phones, might be more appealing to older adults users. Getting an audio feedback on top of having a visual read-out was also very popular among the participants. Older adults who have difficulty seeing their results could benefit from having the audio feedback. Similarly, older adults who have difficulty hearing could benefit from visual cues, such as reminders/alarms that use light instead of sound.

The cost of obtaining and maintaining mHealth was identified as another barrier to mHealth adoption. Financial cost is especially pertinent to older adults considering that the majority of them are retired and would most likely be on fixed incomes. This finding is supported by Steele, Lo, Secombe, & Wong (2009) who reported that cost was the most influential factor when it came to the adoption of wireless sensor technology in older adults. This finding has important research and policy implications. Further
research is needed to determine if mHealth-based HF self management interventions are
cost effective, and if so, changes in policy should be considered in order for the cost of
these technologies to be covered or subsidized by Medicare or private insurance.

Eliminating the cost barrier would help facilitate mHealth adoption among older adults.

Finally, a recommendation from one’s doctor was identified as a contextual
facilitator of mHealth adoption. The trust that older adults have in their doctors and the
perception that their doctors only have their best interest in mind added weight to their
doctor’s recommendation when it came to anything related to their health, even the
adoption of mobile health technology. This finding is supported by Cimperman et al.
(2013) who also found that physicians’ recommendations influenced older adults’
intention to use telehealth services.

While this study yielded important findings on factors that could influence
mHealth adoption among older adults with HF, it is not without limitations. First, the
study was confined to one geographical setting (an urban area in the United States),
which could limit the generalizability of our findings. However, generalizability was not
the major concern of this qualitative study, rather our purpose was to gain a deeper
understanding of older adults’ perceptions of mHealth. In addition, care was taken to
ensure that older adults with varying intention to use mHealth were included in the study
in order to minimize selection bias. Finally, we acknowledge that our findings could
potentially be biased by our beliefs and assumptions. We tried to address this issue by
evaluating the findings among our group and by presenting multiple participant quotes to
substantiate our interpretation.
In summary, this qualitative study explored the perceptions of older adults regarding the use of mobile health technology to help manage their HF. Potential facilitators and barriers to mHealth adoption were identified that could help guide the development and implementation of future mHealth-based HF self-management interventions. Overall, the findings suggest that older adults are willing to use mobile health technology albeit not without reservations. Future researchers looking to implement mHealth-based interventions should address the person-related, technology-related, and contextual barriers, at the same time capitalize on the influence of potential facilitators, such as the doctor’s recommendation, to promote mHealth adoption.
CHAPTER 5
Summary

mHealth, or the use of mobile and wireless devices, such as mobile phones, tablets, wearable sensors, and mobile applications (apps), to support the achievement of health objectives,¹ has the potential to revolutionize HF self-management. In order to realize mHealth’s full potential it is essential to explore potential facilitators and barriers to its adoption, particularly among the older population, who continue to lag behind their younger counterparts when it comes to technology adoption.²

A cross-sectional, sequential explanatory mixed-methods study was conducted to systematically investigate the characteristics and perceptions of older adults that influence their intention to use mobile health technology for HF self-management. An adapted Technology Acceptance Model was used to guide the study.

A total sample of 129 older adults with HF (in-person: n=29, online=100) participated in the study. A purposive sample of 10 in-person participants was interviewed for the qualitative phase of the study.

Hierarchical regression analysis was used to test hypotheses 1.1 to 2.3, the results of which are shown in the table below.

Table 1. Results of the Hypothesis Testing

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>β</th>
<th>P-value</th>
<th>Supported?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 eHL → PEOU</td>
<td>0.20</td>
<td>&lt;0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>1.2 SI → PU</td>
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<td>&lt;0.001</td>
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<tr>
<td>1.3 PEOU → PU</td>
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<tr>
<td>2.1 PEOU → BI</td>
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<tr>
<td>2.3 PFC → BI</td>
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</tr>
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</table>

eHL- eHealth Literacy; PEOU – Perceived Ease of Use, SI – Social Influence, PU – Perceived Usefulness, PFC – Perceived Financial Cost, BI – Behavioral Intention (intention to use mHealth)

To test whether Perceived Ease of Use moderated the relationship between Perceived Usefulness and Behavioral Intention (hypothesis 3.1), an interaction term was
added to the model. The interaction term was not statistically significant ($\beta=0.01, P=0.402$) indicating a lack of evidence to support the hypothesis that Perceived Ease of Use moderated the relationship between Perceived Usefulness and Behavioral Intention. Baron and Kenny’s test for mediation\(^3\) was used to test hypotheses 3.2 and 3.3. eHealth Literacy was not significantly associated with Behavioral Intention ($\beta=0.01, P=0.731$); therefore, hypothesis 3.2 was not supported by the findings. On the other hand, the relationship between Social Influence and Behavioral Intention was partially mediated by Perceived Usefulness.

Qualitative content analysis was used to analyze the qualitative interviews, which revealed the following themes: (facilitators) previous experience with mobile technology, willingness to learn mHealth, ease of use, presence of useful features (e.g. large display, audio function, automatic data transfer), adequate training, free equipment, and doctor’s recommendation; (barriers) lack of knowledge regarding how to use mHealth, decreased sensory perception (i.e. poor vision and/or hearing), lack of need for technology, poorly-designed interface, cost of technology, and limited/fixed income.

To address the mixed-methods aim, the participants were grouped according to their intention to use mHealth score (high, moderate, low) and the facilitators and barriers (themes) identified from their qualitative interviews were then described and compared using a data display table. Adequate training (contextual factor) was consistently identified as a facilitator across the three groups. Similarly, lack of knowledge (person-related factor) was consistently identified as a barrier across the three groups. (Table 2)
<table>
<thead>
<tr>
<th>Intention to Use mHealth</th>
<th>Qualitative Themes</th>
<th>Facilitators</th>
<th>Barriers</th>
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<td><strong>High (score ≥12)</strong></td>
<td>Person-related factors:</td>
<td>Previous experience with mobile technology</td>
<td>Person-related factors:</td>
</tr>
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<td>n=5</td>
<td>Technology-related factors:</td>
<td>Presence of useful features * Ease of use</td>
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<td></td>
<td>Contextual factors:</td>
<td>Adequate training</td>
<td>Contextual factors:</td>
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<td><strong>Moderate (7 ≤ score ≤ 11)</strong></td>
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<td>Willingness to learn mHealth</td>
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<td>Contextual factors:</td>
<td>Adequate training</td>
<td>Contextual factors:</td>
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<td><strong>Low (score ≤6)</strong></td>
<td>Person-related factors:</td>
<td>- none identified</td>
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<td>n=2</td>
<td>Technology-related factors:</td>
<td>Presence of useful features (audio function, automatic data transfer) * Ease of use</td>
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<td>Contextual factors:</td>
<td>Adequate training * Doctor’s recommendation * Equipment provided for free</td>
<td>Contextual factors:</td>
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Contribution to Related Field of Science

In conclusion, the findings of this study can facilitate the implementation of mHealth in HF self-management by addressing the gap in knowledge regarding individual characteristics and perceptions that influence intention to adopt mHealth among older people with HF. Furthermore, the study has the potential to serve as a foundation for addressing health disparities by informing the design of truly patient-centered mHealth interventions.
REFERENCES
References for Chapter 1


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42. Suki NM, Suki NM. Exploring the relationship between perceived usefulness,


References for Chapter 4

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http://nsuworks.nova.edu/tqr%5Cnhttp://nsuworks.nova.edu/tqr


http://doi.org/10.1016/j.ijmedinf.2014.01.004


http://doi.org/10.1177/0733464815624151

http://doi.org/10.1038/nrcardio.2011.95

http://doi.org/10.2196/jmir.1909

http://doi.org/10.1016/j.ijmedinf.2009.08.001


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http://doi.org/10.1080/03601277.2015.1048165


http://doi.org/10.1007/s11897-012-0114-8


http://doi.org/10.1161/CIR.0b013e31829e8776
References for Chapter 5


Curriculum Vitae

PERSONAL DATA

Maan Isabella Cajita
525 N. Wolfe Street,
Student House, Room 310
Baltimore, MD 21205
443.570.7329
mcajita1@jhu.edu

EDUCATION

<table>
<thead>
<tr>
<th>Year</th>
<th>Degree Earned</th>
<th>Institution/Location</th>
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| 2017   | Doctor of Philosophy (Nursing) | Johns Hopkins University
Baltimore, MD |
| 2013   | Bachelor of Science (Nursing)  | University of Illinois at Chicago
Chicago, IL  |
| 2007   | Associate Degree (Nursing)     | Morton College
Cicero, IL  |

CURRENT LICENSE AND CERTIFICATION

<table>
<thead>
<tr>
<th>Year</th>
<th>Source</th>
<th>Type, Certification/License #</th>
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<tr>
<td>2012 - present</td>
<td>Maryland Department of Health and Mental Hygiene – Board of Nursing</td>
<td>Registered Nurse, R202803</td>
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<td>2007 - present</td>
<td>State of Illinois Department of Financial and Professional Regulation</td>
<td>Registered Professional Nurse, 041.362023</td>
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<tr>
<td>2012 - 2013</td>
<td>Commonwealth of Pennsylvania Department of State – Bureau of Professional and Occupational Affairs</td>
<td>Registered Nurse, RN638773</td>
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<td>2012 - 2017</td>
<td>American Nurses Credentialing Center</td>
<td>Gerontological Nursing Certification, 2011020435</td>
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<td>2010 - 2020</td>
<td>American Nurses Credentialing Center</td>
<td>Cardiac Vascular Nursing Certification, 2009012002</td>
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PROFESSIONAL EXPERIENCE

<table>
<thead>
<tr>
<th>Year</th>
<th>Position</th>
<th>Institution/Location</th>
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</table>
| 2007 - 2013| Staff Nurse, Charge Nurse   | Macneal Hospital
Berwyn, IL  |
HONORS AND AWARDS

2016    Mathy Mezey Endowed Scholarship Fund recipient
2014 - 2016 Jonas Nurse Leader Scholar
2013    High Academic Honors, University of Illinois at Chicago
2012 - present Sigma Theta Tau, Alpha Lambda Chapter, University of Illinois at Chicago
2004 - 2007 Dean’s List/President’s List, Morton College
2004 - 2007 Phi Theta Kappa Honor Society, Morton College

RESEARCH SUPPORT

Sponsored Projects
2015 - 2017 PI (100%) *mHealth Use in Older People with Heart Failure*
NIH/NINR Ruth L. Kirschstein National Research Service Awards for Individual Pre-doctoral Fellows in Nursing Research 1F31NR015943-01
2016 PI (100%) *mHealth Use in Older People with Heart Failure*
Heart Failure Society of America Nursing Research Mini Grant
2016 PI (100%) *mHealth Use in Older People with Heart Failure*
Council for the Advancement of Nursing Science/Southern Nursing Research Society Nursing Science Advancement (NSA) Dissertation Grant Award

Research and Educational Grants
2015 - 2016 NIH 5TL1TR001078-02 Multidisciplinary Predoctoral Clinical Research Training Program (PI: Beach, MC) – terminated in order to activate NRSA

PROFESSIONAL ACTIVITIES

2015 – present Southern Nursing Research Society, student member
2015 – present The Council for the Advancement of Nursing Science, student member
2015    Patient-centered Scalable National Network for Effectiveness Research (pSCANNER) Project, PCORI Grant-Advisory Panel member
2014 – present Heart Failure Society of America, member
2014 – present Healthcare Information and Management Systems Society, member
2013 – present The Gerontological Society of America, member, abstract reviewer
2012 – present Preventive Cardiovascular Nurses Association, member

SCHOLARSHIP

Journal Articles:


In Press:


4. **Cajita MI**, Hodgson N, Budhathoki, Han HR. Intention to use mHealth in older adults with heart failure *Journal of Cardiovascular Nursing*. 2017. doi:


In Review:


Presentations:
Regional
1. **Cajita MI**, Han HR. mHealth use in older adults with heart failure. 31st Annual Southern Nursing Research Society Conference. Dallas, TX. February 22-25, 2017. (Poster/Podium presentation)
National


International