CLINICIANS' ACCEPTANCE OF INTERACTIVE HEALTH TECHNOLOGIES TO SUPPORT PATIENT SELF-MANAGEMENT

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Background: The use of interactive health technologies (IHTs) by patients and clinicians may promote self-management behaviors, and thus help prevent, detect and treat complications. Yet, clinicians' acceptance of IHTs is low and not well understood. The purpose of this study was to identify the factors that influence clinicians' intention to use IHTs.

Methods: A conceptual model of factors thought to influence clinicians' intention to use IHTs was generated from the literature and evaluated using a mixed-methods design. Clinicians completed a survey on-line to measure the relationships between concepts of the proposed model. The data were analyzed using partial least squares structural equation modeling. Purposive, criterion sampling was used to select a representative subgroup of clinicians for follow-up interviews. Thematic analysis was used to summarize the interview data. Findings of the surveys and interviews were integrated using importance-performance matrix analyses (IPMA).

Results: The sample included 82 clinicians; 70% female, 17% physicians, 40% transplant clinicians, and ages ranged from 25-65 years. Perceived usefulness was the only direct predictor of intention to use ($b= 0.52$, $p <.001$; $R^2=.64$). Subjective norms, views of other colleagues, ($b= 0.25$, $p <.001$) and compatibility with work style ($b= 0.66$, $p <.001$) were significant predictors of perceived usefulness. Perceived ease of use ($b= 0.54$, $p <.001$) and facilitating conditions (e.g., organizational support, $b= 0.27$, $p <.001$) significantly influenced compatibility. Clinicians' beliefs about patient self-management ($b= 0.46$, $p <.001$) significantly influenced subjective norms. The

interviews (n=6) confirmed and further explained the survey findings. Three distinct groups of clinicians emerged from the qualitative analysis and the IPMA. Nurses and care coordinators were more concerned about details in IHTs and the availability of adequate organizational resources. Physicians were more interested in the overall picture and the compatibility of IHTs with their workflow. Advanced practice providers were willing to follow patients on a daily basis but only in the ambulatory setting.

Conclusions: The usefulness and compatibility with clinicians' workflow are among the top priorities for successful deployment of IHTs. Future IHTs should be tailored for different types of clinicians. These findings have implications for policy makers, healthcare organizations, designers and researchers.

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PREFACE

This document was prepared for the final PhD dissertation defense on November 21, 2017 at the University of Pittsburgh School of Nursing. The study was supported through funding from the Margaret E. Wilkes Scholarship Fund Award at the University of Pittsburgh School of Nursing, the Nursing Health Sciences and Allied Health Research Grant of the International Society for Heart and Lung Transplantation (ISHLT), and the Pre-doctoral Fellowship T32 2NR008857: Technology Research in Chronic and Critical Illness (2015-2017). I would like to recognize the contributions of my committee chair and members. I also would like to thank my parents, family and friends for their support and encouragement.

1.0 INTRODUCTION

Chronic diseases are considered the leading cause of mortality, morbidity and health resource utilization in the world except for Africa (McDermott & While, 2013; World Health Organization, 2011). Of particular concern are the cardiopulmonary diseases (e.g., heart failure, cardiovascular disease, chronic obstructive lung disease) that remain the major causes of death during the past decade (World Health Organization, 2014). Accordingly, management of such conditions requires extended and continuous follow-up with emphasis on self-management that assists in the tertiary prevention of complications related to these diseases (Lorig & Holman, 2003; Schulman-Green et al., 2012).

Interactive health technologies (IHTs) are designed to encourage patients' self-management through the use of mobile health technologies that provide flexible and real-time monitoring, detection of changes in health status, and the ability to deliver interventions (Kumar, Nilsen, Pavel, & Srivastava, 2013; Lanseng & Andreassen, 2007; Shahriyar, Bari, Kundu, Ahamed, & Akbar, 2009). Furthermore, IHTs facilitate patient-clinician communication by connecting patient terminals (mobile applications) to clinician web-based portals for personalized feedback (De Vito Dabbs et al., 2009; Kollmann, Riedl, Kastner, Schreier, & Ludvik, 2007). Understanding clinicians' perspectives is crucial because the success and innovation of these IHTs depend on the collaboration between clinicians and designers (Chatterji, Fabrizio, Mitchell, & Schulman, 2008). In addition, clinicians often make recommendations about the suitability and

type of IHTs for their patients (P. Y. K. Chau & P. J.-H. Hu, 2002; Shah, Barnett, Kuljis, Hone, & Kaczmarski, 2013). While most existing studies discuss patients' perceptions of IHTs, little is known about clinicians' acceptance and intention to use such technologies. Hence, the objective of this mixed-methods study was to explore the factors influencing clinicians' intention to use IHTs to support self-management for patients with chronic cardiopulmonary diseases.

1.1 SPECIFIC AIMS

To achieve the objective of this study, the specific aims were:

Aim 1. Systematically review the literature regarding the factors impacting clinicians' acceptance of IHTs to support patient self-management.

Aim 2. Quantitatively evaluate a proposed conceptual model to explain the influence of professional, technological, and organizational factors on clinicians' intention to use IHTs for patient self-management.

Aim 3. Qualitatively explore the factors that influence clinicians' intention to use IHTs.

Aim 4. Integrate the findings from the quantitative and qualitative inquiries to provide a multi-dimensional, rich description of factors that influence clinicians' intention to use IHTs.

1.2 BACKGROUND

1.2.1 Chronic Cardiopulmonary Diseases

The World Health Organization lists cardiovascular and respiratory diseases among the top three non-communicable (chronic) causes of mortality worldwide (World Health Organisation, 2015). Similarly, the Centers for Disease Control and Prevention (CDC) reports heart diseases and chronic lower respiratory disease among the top 3 causes of death in the United States (Heron, 2016). These disorders include a variety of diagnoses that affect the cardiovascular or pulmonary systems such as coronary artery disease (CAD), heart failure (HF), and chronic obstructive pulmonary disease (COPD) (Hawkins, Virani, & Ceconi, 2013; Ukena et al., 2010).

The prevalence of chronic cardiopulmonary diseases is expected to grow as advances in the management of acute cardiopulmonary diseases, particularly in developed countries, has led to increased survival rates but also higher prevalence of chronic cardiopulmonary diseases during the life-years gained (Geersing, de Groot, Reitsma, Hoes, & Rutten, 2015). These chronic diseases have a dramatic impact on patients and their caregivers and are accompanied by significant symptom burden and poor quality of life (Bidwell et al., 2015; Ukena et al., 2010). In addition, patients are usually older with multiple comorbidities, which make management of their interdependent and co-occurring conditions more challenging (Braunstein et al., 2003; Levy et al., 2002). For example, the presence of three or more cardiac and non-cardiac comorbidities was found to be associated with higher morbidity and mortality rates (Bohm et al., 2015). This complexity implies the adoption of more holistic approaches in the treatment of these disorders (Geersing et al., 2015) and the notation of viewing them in the design of systematic disease continuum (Ukena et al., 2010).

1.2.2 Self-Management and Barriers to Adherence

Self-management can be defined as a dynamic and interactive process in which individuals (patients and clinicians) collaborate to prevent and provide early detection of problems that arise with chronic illness (Lorig & Holman, 2003; Schulman-Green et al., 2012). Previous reports have shown that patient engagement in self-management behaviors is crucial for controlling the progression of cardiopulmonary diseases. For example, self-management education programs including content about the medical regimen, behavioral health change, and emotional support for patients to control their disease (Sohanpal, Seale, & Taylor, 2012), reduced readmission rates and mitigated exacerbations among patients with COPD (Effing et al., 2007). Similar programs for patients with heart failure (HF) were found to reduce readmissions, mortality and the cost of care (Barbara Riegel et al., 2009).

Despite the obvious advantages and the persistent recommendations for self-management and pulmonary rehabilitation programs among patients with cardiopulmonary diseases, several studies reported poor patient participation and high drop-out rates (Goldstein et al., 2014). Experience with illness, physical functioning, psychological problems (anxiety and depression), and social support were found to be factors influencing self-management among patients with HF (B. Riegel, Lee, Dickson, & Medscape, 2011). In their qualitative synthesis of studies about self-management and pulmonary rehabilitation programs for COPD, Sohanpal and colleagues identified physical and practical concerns related to attendance, such as personal and professional commitments, as one of the major barriers to non-adherence and program drop-out (Sohanpal, Steed, Mars, & Taylor, 2015). A possible solution is the introduction of home-based pulmonary rehabilitation programs, an alternative that is subject to the degree of patient's motivation and interest (Sohanpal et al., 2015). Out-of-office communication between clinicians and patients is

pivotal at this point to reduce the social distance between patients and clinicians, diminish the traditional power differential, and thus enhance patient confidence, role, and engagement in health self-management and planning (Alexander, Hearld, Mittler, & Harvey, 2012). However, lack of time and financial difficulties hinder the effective communication between patients and their clinicians when they need to (Bitsaki et al., 2016), which might negatively impact the self-management process and result in the exacerbation of the chronic condition. Therefore, there was a necessity to introduce innovative methods that assist in mitigating the impact of such barriers and allow remote real-time self-monitoring and communication between patients and clinicians.

1.2.3 Interactive Health Technologies

Mobile technologies, including smartphones, are becoming increasingly ubiquitous, reaching a broad range of users worldwide. There are more than 285 million wireless subscribers in the United States alone, and about 96% of the United States is covered by at least one mobile network (National Institute of Health, 2013). In 2015, around 64% of American adults owned smartphones compared to 35% in 2011, and 62% of those owners have used their smartphones to look up information about a health condition (Smith, 2015). The widespread use of mobile technologies has the potential to have a significant influence on public health and healthcare delivery by employing interactive health technologies (IHTs) that provide the means for communication between patients and their clinicians. This can influence when, where and how to deliver healthcare and will open the door for innovation and introduction of new applications in the healthcare field.

IHTs are defined as computerized technologies that allow the user-- consumer, patient, caregiver, or professional-- to access, monitor, share, or transmit health information (Robinson, Patrick, Eng, & Gustafson, 1998). The term IHTs is specific to the communication and software

programs for users regardless of the platform in use (desktops, tablets, and smartphones) (De Vito Dabbs et al., 2009). This term is similar to "interactive medicine" term that was used in a recent Cochrane systematic review to describe the technologies in which healthcare professionals respond to the transmission of information from patients (Flodgren, Rachas, Farmer, Inzitari, & Shepperd, 2015). In this dissertation, the term IHTs was used to refer to clinicians' use of web portals to communicate with patients who record and share their health data with clinicians via mobile applications that are designed to run on smartphones or tablet devices (Janssen, 2014). Although these apps provide specific and limited functionality, they are preferred by users over mobile websites, which are designed to run on mobile web browsers, because they are user-friendly and they can target the limitations and abilities of the mobile device being used (Janssen, 2014; Nielsen, 2012).

Several studies were conducted using mobile apps with cardiopulmonary patients. Smartphones were found to be a feasible way of delivering cardiac rehabilitation, education and promoting patient adherence to the minimum recommended daily activity (Vathsangam et al., 2015). In their randomized controlled trial (RCT), Varnfield et al. (2014) reported that the use of an IHT (Care Assessment Platform of CR [CAP-CR]) to connect post-myocardial infarction patients with their healthcare providers improved initial uptake, adherence over time, and completion of cardiac rehabilitation. Furthermore, patients randomized to the IHT group showed comparable improvements in physical and physiological health outcomes, such as 6-minute walk test, emotional state, and quality of life, compared to those in the traditional center-based group (Varnfield et al., 2014).

On the other hand, studies of IHTs for persons with chronic pulmonary disease showed positive improvements in patients' self-management behaviors but mixed evidence with regard to

health outcomes. A RCT comparing the effect of a mobile IHT, Pocket PATH®: Personal Assistant for Tracking Health to usual care on self-management among lung recipients within the first year after lung transplantation, found improved self-monitoring (e.g. spirometry, vital signs, symptoms), adherence to medical regimen, and communication of abnormal health indicators to their healthcare providers, but no improvement was detected in health outcomes such as hospital admission or mortality (DeVito Dabbs et al., 2016). Similarly, Sicotte, Pare, Morin, Potvin, and Moreault (2011) reported that the use of an IHT improved satisfaction with care, empowerment, and quality of life among COPD patients, but had no impact on hospital admissions or emergency room visits. Previous systematic reviews showed that home telehealth among COPD patients was effective in reducing rates of hospital admissions and emergency department visits (Polisena et al., 2010), and improving physical activity level, but not physical capacity or dyspnea (Lundell, Holmner, Rehn, Nyberg, & Wadell, 2015).

1.2.4 Gaps Identified in the Literature

Reviewing the literature, several gaps were identified with regard to the use IHTs. The current health behavior and technology acceptance theories appeared to be inadequate for guiding the development of new adaptive and interactive interventions delivered using IHTs that require the utilization of longitudinal data collected and communicated via mobile devices (Riley et al., 2011). The vast majority of theories and theoretical constructs used in understanding the implementation of IHTs were developed outside the healthcare paradigm and do necessarily not tap the unique and contextual necessities of the healthcare setting (P. Y. K. Chau & P. J. Hu, 2002; Holden & Karsh, 2010).

In addition, in spite of its importance, there is a paucity of research that addresses IHTs use for self-management from the perspective of clinicians. Only a few studies of IHTs explored the views of clinicians caring for patients with chronic diseases such as diabetes (Okazaki, Castaneda, Sanz, & Henseler, 2012), mental health (Kuhn et al., 2014), and cardiopulmonary diseases (Asua, Orruño, Reviriego, Gagnon, & Orruno, 2012; M. P. Gagnon, Orruno, Asua, Abdeljelil, & Emparanza, 2012). These studies were limited by the lack of appropriate use of theories for the target setting. For example, Okazaki et al. (2012) surveyed Japanese physicians about their intention to use an IHT intervention for self-care among patients with diabetes. The investigators used a modified version of the updated DeLone and McLean model (DeLone & Mclean, 2003), which is more suitable to measure system success after implementation at both the individual and organizational levels rather than an individual's intentions. Furthermore, modifying the model with generic constructs from outside the healthcare field, such as privacy and security risks, may explain why many of the proposed relationships were not statistically significant (Okazaki et al., 2012).

The other two studies that explored healthcare professionals' perspectives about the use of IHTs with cardiopulmonary patients have used theoretical frameworks that were modified versions of the technology acceptance model (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012). However, a few limitations were noted. First, the response rate was low, which might impact the generalizability of the findings and may indicate the possibility of participation bias. Second, some participants had previous experience with the tested IHT while others had not, and the authors did not account for such experience variation in the model. Previous studies have shown the moderation effect of previous experience on some determinants of technology acceptance such as perceived ease of use (Venkatesh & Bala, 2008). Third, as in previous reports, the studies did not account for clinicians' perception of patient empowerment and engagement in care planning,

factors known to impact their beliefs and behaviors regardless of the mode of communication, be it during face-to-face visits or remote using IHTs. Previous research showed that physicians vary regarding the degree to which they believe their patients should be empowered (Dabbs, Kim, Hamdan-Mansour, Thibodeau, & Curry, 2006; J. H. Hibbard, Collins, Mahoney, & Baker, 2010). For these reasons, there is a need for more research to develop powerful theoretical models that are capable of explaining clinicians' acceptance of IHTs to support self-management of patients with cardiopulmonary diseases.

1.3 THEORETICAL FOUNDATION

1.3.1 The Technology Acceptance Model

Several theoretical models about adoption and use of new technologies have been proposed. Among the first theories to be applied were the Theory of Reasoned Action (TRA) (Fisbein & Ajzen, 1975), the Technology Acceptance Model (TAM) (F.D. Davis, 1989; F. D. Davis, Bagozzi, & Warshaw, 1989), the Theory of Planned Behavior (TPB) that combines both TRA and TAM (Ajzen, Netemeyer, & Ryn, 1991), and the Innovation Diffusion Theory (Rogers, 2010).

Because of its relative simplicity and ability to explain considerable variance (around 40%) in users' intention to use new technologies, the TAM compares favorably to other models (TRA and TBP) and thus has been extensively and empirically tested in the literature and found to be parsimonious (P. Y. K. Chau & P. J.-H. Hu, 2002; Hong, Thong, & Tam, 2006; Venkatesh & Davis, 2000). Indeed, the TAM is the most popular model among its counterparts and accounts for about 30-40% of the literature about information technology acceptance (Holden & Karsh, 2010).

The TAM was based on the TRA and purports that internal beliefs mediate the impact of external variables (e.g., task and user characteristics) on intention to use and the actual use of technology (F. D. Davis et al., 1989) (Figure 1). More specifically, perceived ease of use and perceived usefulness are the main determinants of users' intentions and actual use of new technologies.

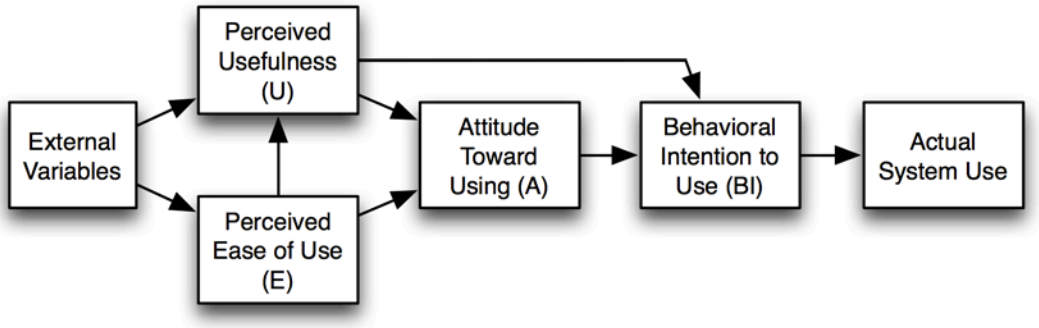

Figure 1. Technology Acceptance Model (TAM) (F. D. Davis et al., 1989)

The extensive utilization of the TAM resulted in a better understanding of its underlying concepts and the relationships between them and its strengths and weaknesses. Hence, the original model was refined and expanded with the major upgrades revisions being the Technology Acceptance Model 2 (TAM2), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003), and finally TAM3 (Venkatesh & Bala, 2008). In TAM2 (Figure 2), Venkatesh and Davis (2000) aimed for a modified model that accounted for the human and social aspects of users. The external variables were replaced by additional key determinants of perceived usefulness, and the "attitudes toward using" variable was omitted. In addition, the original TRA variable of "subjective norms" (social influence) was included as a third predictor of intention to use, and the relationships between subjective norms and the other variables are moderated by experience and voluntariness. These enhancements

increased the variance explained in intention to use from around 40% to 52% (Venkatesh & Davis, 2000).

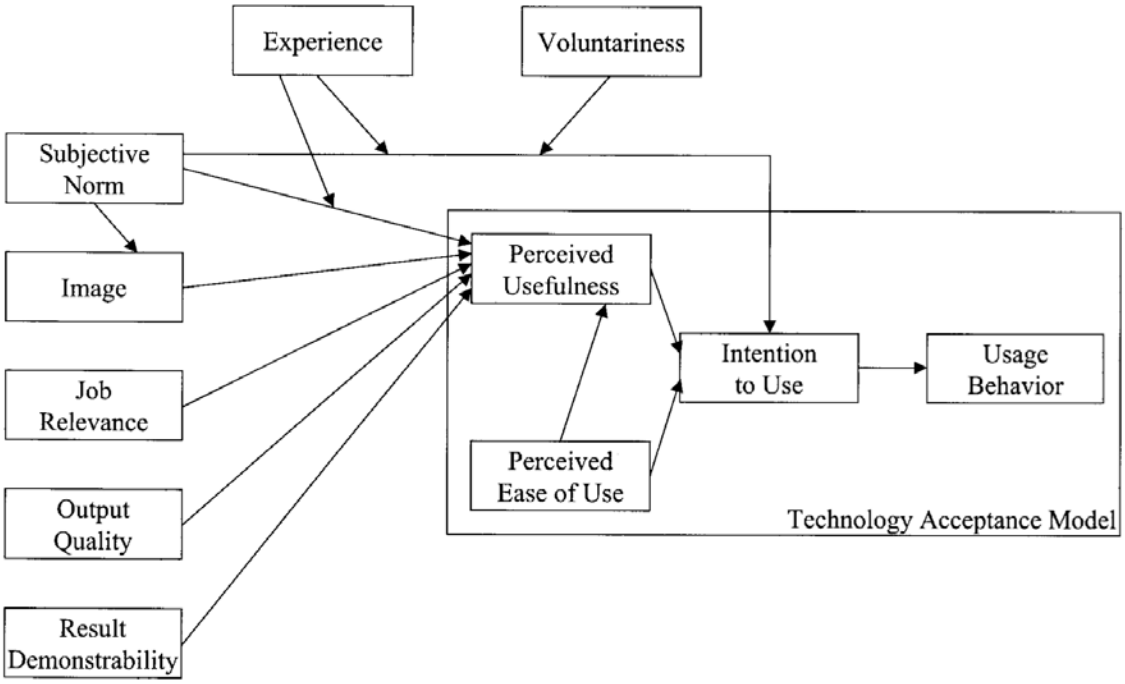

Figure 2. Technology Acceptance Model 2 (TAM2) (Venkatesh & Davis, 2000)

The UTAUT (Figure 3) includes the primary variables from the TAM and added other the determinants of intention to use technology from different theories and stratified them to create three constructs: performance expectancy, effort expectancy, and social influence (Venkatesh et al., 2003). These three constructs are the counterparts for the TAM2 variables of perceived usefulness, perceived ease of use, and subjective norms, respectively. The facilitating conditions (organizational support), a construct similar to perceived behavioral control in the TPB was purported to predict actual use behavior but not intention to use.

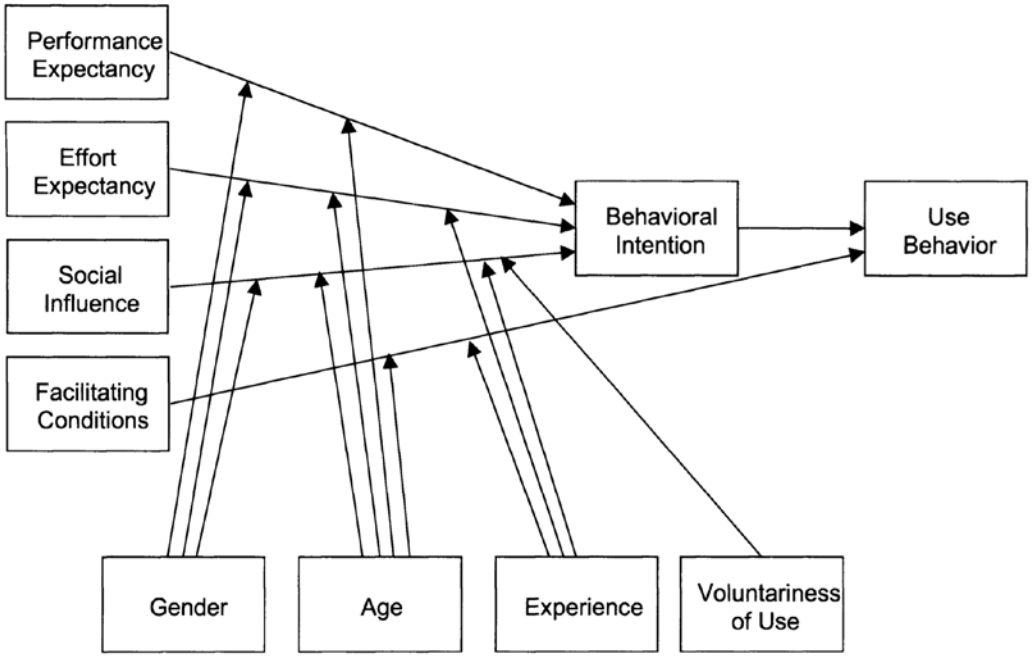

Figure 3. The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003)

The TAM3 (Figure 4) was introduced in 2008 after two decades of ongoing testing and implementation in the field. The main updates included determinants of perceived ease of use by utilizing the anchoring and adjustment notion of human decision making (Venkatesh & Bala, 2008). The authors argued that the inclusion of such variables aid managers to develop more informed decisions about the intervention strategies that lead to an efficient utilization of the new technology.

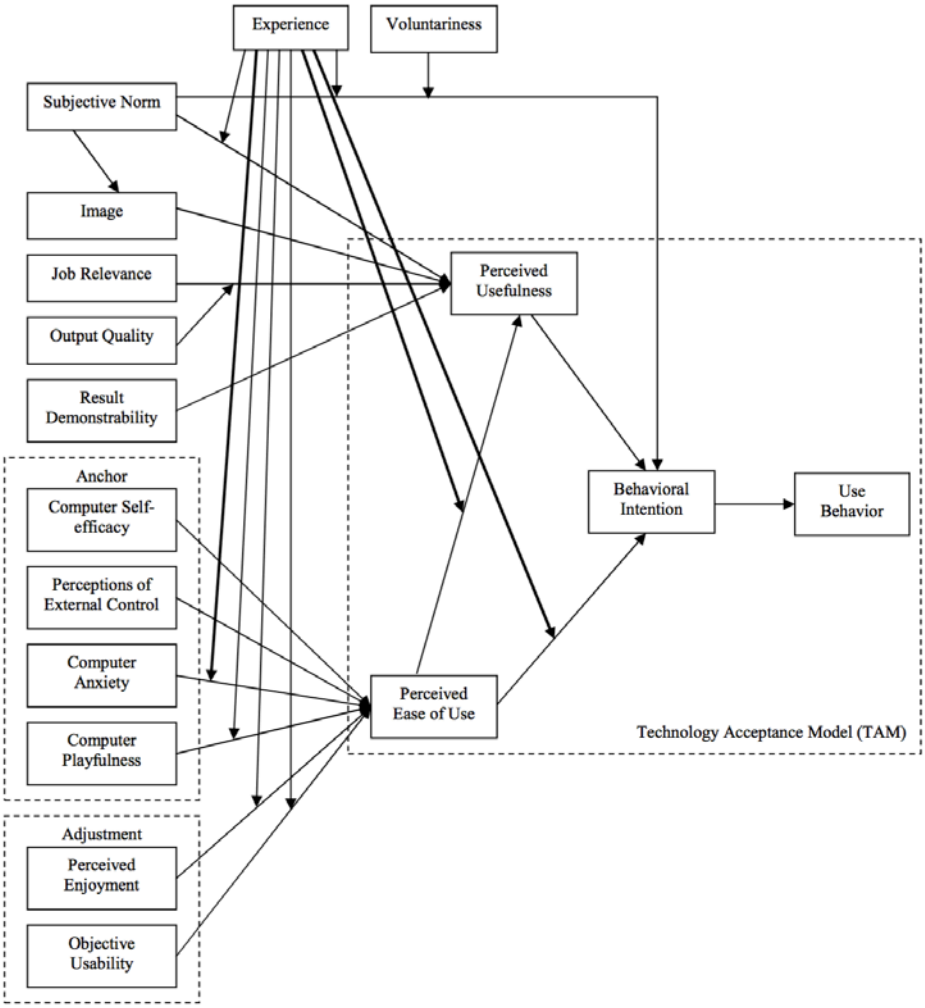

Figure 4. The Technology Acceptance Model 3 (TAM3) (Venkatesh & Bala, 2008)

1.3.2 The Proposed Model

Following the introduction of TAM, the need for more sophisticated and specific theoretical models of technology acceptance was recognized. For example, Davis (1993), the author of the original TAM, has stated that the model should be finely grained to represent the needs and features of the technology to be adopted (F.D. Davis, 1993). Indeed, TAM should incorporate more variables or integrate with other models in the field in order to improve its predictability and the explanatory power, particularly when applied to technology acceptance in the healthcare context

(Hu, Chau, Liu Sheng, Tam, & Sheng, 1999). Furthermore, when healthcare professionals' acceptance of telemedicine technology was examined, P. Y. K. Chau and P. J.-H. Hu (2002) recognized the need to explore variables beyond those in the original TAM and other theories (such as TPB).

As a response to these calls , in this dissertation I propose a modified and enhanced version of the TAM that includes constructs from the UTAUT (Venkatesh et al., 2003) and other instruments from within the healthcare field (J. H. Hibbard et al., 2010) to fit the context and setting of IHTs. The approach of adding variables is the dominant method for enhancing and testing the TAM in healthcare (Holden & Karsh, 2010), and it is also a common and efficient method for expanding and deepening current behavioral frameworks and theories (Conner & Armitage, 1998; Langdridge, Sheeran, & Connolly, 2007; Perugini & Bagozzi, 2001). For example, further exploration and expansion of the original TAM led to the development of TAM2 (Venkatesh & Davis, 2000) and finally TAM3 (Venkatesh & Bala, 2008). Many researchers have defended the feasibility of this approach with TAM and argue that it is a good approach to improve knowledge about acceptance of IHTs, in general (Yi, Jackson, Park, & Probst, 2006).

In their study that describes physicians' acceptance of telemedicine, P. Y. K. Chau and P. J.-H. Hu (2002) laid the groundwork for a framework that is an adaptation of TAM and a better fit for clinicians. The authors categorized the determinants of intention to use into individual (professional), technological, and implementation (organizational) contexts. Accordingly, I followed a similar approach in my enhanced model that is tailored to meet the needs of our niche population, i.e. clinicians using IHTs to support self-management for patients with cardiopulmonary disorders (Figure 5).

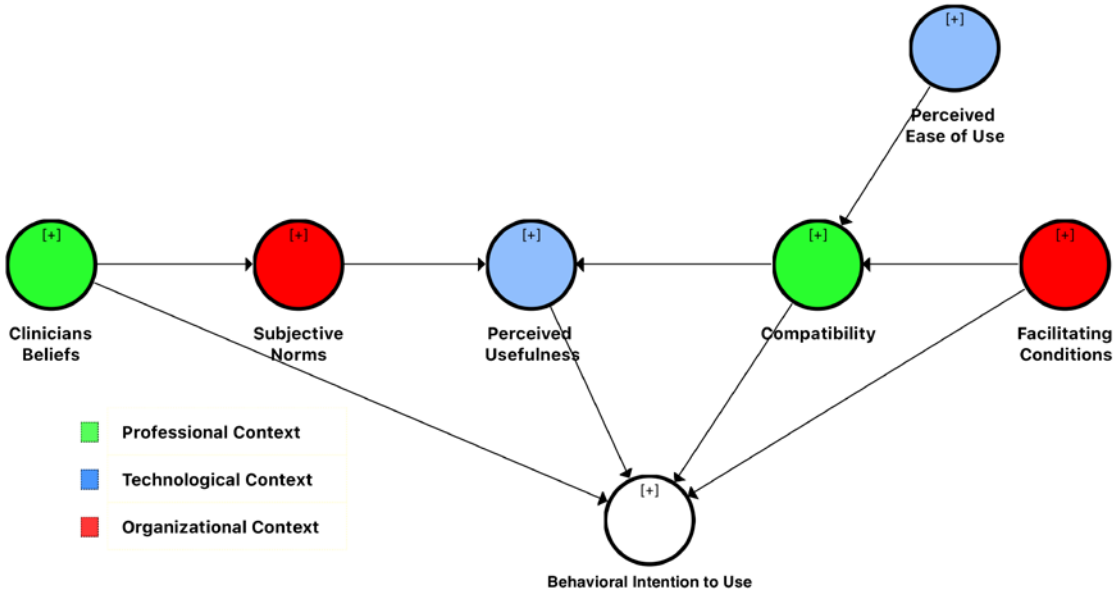

Figure 5. Proposed conceptual model for clinicians' acceptance of IHTs to support patient self-management

1.3.2.1 Intention to Use

While actual use is the precise way to measure the adoption of any given system, sometimes the direct measure of use is not possible or realistic. Multiple methods were proposed to measure use (Petter, DeLone, & McLean, 2008), some of which were not representative of adoption and/or subject to great disagreement among researchers. While some studies support using sensible metrics, such as the amount, duration, and frequency of use, to measure technology use, others viewed it as a multilevel concept that should be understood at individual and organizational levels (Burton-Jones & Gallivan, 2007) or as a set of interdependent variables that mediate the impact of social and economic factors of technology on work (Doll & Torkzadeh, 1998).

Hence, it was more feasible and practical to have a behavioral measure, such as intention to use, to express users' likelihood of using the new technology (Petter, DeLone, & McLean, 2013). This follows the reasoning that an individual's decision to accept technology is a justifiable

and conscious act that can be predicted by behavioral intention (P. Y. K. Chau & P. J. Hu, 2002). When individuals hold intentions to act, they will freely act without limitations unless they are presented with practical concerns, such as limited ability, time, environmental or organizational limits, or unconscious habits limiting their freedom to act (Dwivedi, Wade, & Schneberger, 2011). According to the TAM, when users are presented with a new technology, their acceptance to use this technology is expressed in their behavioral intention to use it (F.D. Davis, 1989; Mathieson, 1991). Behavioral intention to use (BIU) was extensively used in the literature, such as physicians' acceptance of telemedicine (M. P. Gagnon, Orruno, et al., 2012), and was empirically reported to have a direct significant relationship with the actual use (Penttinen, Rinta-Kahila, Ronkko, & Saarinen, 2014; Venkatesh et al., 2003). Similar to the TAM, BIU was considered the outcome variable in our model, and it is purported to be directly determined by the independent variables in the professional, technological, and organizational contexts (Figure 5).

1.3.2.2 Professional Context

Professional context is similar to the individual context described by P. Y. K. Chau and P. J. Hu (2002) that includes the specific characteristics of the users. Since any group of users, such as clinicians, may exhibit different characteristics than those of other groups, they would have different intentions towards technologies (P. Y. K. Chau & P. J. Hu, 2002). In our model, the target group is only clinicians and thus we labeled this context as professional. Therefore, this was added to the model to address the effect of healthcare professionals' norms and values on the adoption of the new IHTs, and it includes only two variables: clinicians' beliefs about self-management and compatibility.

Clinicians' Beliefs about Self-Management

Several studies reported the importance of clinician recommendation on patient decisions to participate in self-management behaviors and programs, such as CR (Banerjee, Grace, Thomas, & Faulkner, 2010; Clark et al., 2013), and particularly when the patient is incompetent of making such decisions (Neubeck et al., 2012). When they surveyed patients who are enrolled or referred to CR programs about the barriers and motives of enrollment, Lieberman, Meana, and Stewart (1998) found clinicians' recommendation to be the most influencing factor followed by family support. The role of the clinician is pivotal in activating patients to further engage in their own care and achieve their desired health goals. In fact, it was empirically found that positive clinicians' beliefs about patient self-management are directly associated with patient activation (Alvarez, Greene, Hibbard, & Overton, 2016) and perceived quality of care (Ratanawongsa et al., 2012).

Yet, clinicians reportedly resist and even recommend against such programs (Heid & Schmelzer, 2004; McSweeney & Crane, 2001), presumably due to a lack of knowledge about the content and benefits of the programs (Allen et al., 2000; Clark et al., 2013). Many clinicians have not received training about strategies to promote patient engagement and do not view patient support as part of their role as clinicians (Alvarez et al., 2016). In addition, professional affiliation was previously found to impact clinicians' level of support of patient self-management. For example, nurses were more supportive of self-management than physicians and other allied healthcare professionals (NHS England, 2015).

Therefore, one of the major shortfalls of research on clinicians' acceptance of IHTs is the erroneous assumption that all clinicians are prepared and committed to supporting patient self-management. In addition, clinicians often assume that barriers to self-management are only on the patient side. In my model, the discrepancy in clinicians' beliefs about patient self-management (CBSM) is hypothesized to directly predict subjective norms (SN), and this relationship is

moderated by professional affiliation (i.e. physician, physician assistant, nurse practitioner, and nurse).

Compatibility

The compatibility (COM) concept was derived from the Innovation Diffusion Theory (Rogers, 2010), and is defined as "the degree to which the innovation is perceived to be consistent with potential users' existing values, prior experiences and needs" (Wu, Wang, & Lin, 2007). In the healthcare setting, COM describes clinicians' resistance to change their routine in response to stress created by using new technology (Jung & Loria, 2010; Venkatesh, Morris, & Ackerman, 2000; Ye, 2008). The concept was widely reported as an influencing factor in explaining the technology acceptance among clinicians (Chau & Hu, 2001; M. P. Gagnon, Orruno, et al., 2012).

The implementation of new IHTs may force clinicians to adjust their work style which may also impact their current clinical practices (Hung, Tsai, & Chuang, 2014). In general, clinicians usually follow certain practice processes of categorization and care plan selection and execution that become more entrenched over time, and thus make clinicians more unlikely to accept new technologies perceived to be incompatible with their work practices (Chau & Hu, 2001). In addition, these practice processes vary among clinicians depending on their distinct epistemic communities, represented by professional affiliations, which creates different knowledge sharing mechanisms and attitudes at the individual and group levels within an organization (Currie & White, 2012; Davies, 2000; White, 2000). Therefore, the described COM is important for explaining and predicting behavioral intentions (Wu et al., 2007) because it taps into the fit between adoption of technological systems in the organizations and individual's work style (Venkatesh et al., 2003). COM was adopted in the purported model as a direct predictor of BIU, and this prediction relationship depends on the professional role of the clinician. It is also predicted

that clinicians will consider IHTs useful in their care if they are consistent with their needs and their clinical work routine.

1.3.2.3 Technological Context

Context is considered the core of TAM, and there has been extensive literature supporting the importance of characteristics of the technology on technology acceptance. To measure how the technology attributes influence a decision to accept, previous studies suggested the use of perceived measures rather than objective ones (Moore & Benbasat, 1991). Hence I followed the common theme in the literature and adopted perceived ease of use and perceived usefulness to evaluate the technological dimension in the model (P. Y. K. Chau & P. J. Hu, 2002).

Perceived Usefulness

Perceived usefulness (PU) is "the degree to which an individual believes that using a particular system would enhance his or her job performance"(F D Davis, 1986). This follows the notion that any system will be viewed as useful when it demonstrates a positive use-benefit relationship (F.D. Davis, 1989). The concept has been consistently reported as the significant determinant of BIU in technology acceptance research (Or & Karsh, 2009; Venkatesh & Davis, 2000).

In a set of three related studies from Spain that used the same conceptual framework with a variety of IHT technologies, inconsistent impact of PU on technology acceptance was reported; PU had a significant positive effect on BIU only in one study (Asua et al., 2012), and was overridden by the effect of facilitating conditions in the other two (M. P. Gagnon, Orruno, et al., 2012; Orruno, Gagnon, Asua, Ben Abdeljelil, & Orruño, 2011). Nevertheless, a plausible explanation for the inconsistencies between these findings is that, we argue, the reported large

discrepancies among centers sampling from; in one case, data from 9 out of 50 centers surveyed were identified as outliers (Orruno et al., 2011). In fact, PU was consistently found to be a major predictor of BIU in the field of telemedicine and IHTs (Rho, Choi, & Lee, 2014). For example, P. Y. K. Chau and P. J. Hu (2002) found PU to be the single most significant determinant of physicians' intention to use telemedicine, indicating their pragmatic view about technology adoption. Hence, we used PU as a direct predictor of BIU in our model.

Perceived Ease of Use

Perceived ease of use (PEOU) is defined as "the degree to which a person believes that using a particular system would be free from effort" (F.D. Davis, 1989, p. 320). A large body of literature has accumulated in support of viewing PEOU, along with PU, as one of the most reliable predictors of technology acceptance (Or & Karsh, 2009; Venkatesh, 2000). That is, users tend to prefer to use less complicated technologies than those that are hard to use. However, in the context of IHTs PEOU was reported not to be a significant predictor for BIU (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012).

After they proposed their initial TAM model, F. D. Davis et al. (1989) differentiated between two versions of the model, pre- and post-implementation. In the former one, PEOU has a direct impact on BIU, however, this relationship is mediated PU in the latter case. The authors argued that with increased experience of using the technology, users start to rely more on their judgments of the usefulness of the system instead of its easiness to use. Although (Szajna, 1996) failed to prove such notion, later research found it to be true (King & He, 2006; Venkatesh, 2000). Venkatesh and Bala (2008) argued that the difficulty of a system to use is an "initial hurdle" when users are presented with a new system, but after a period of hands-on experience, this will diminish. Despite the assumption that system usage is a must in mandatory setting, some users still choose

not to comply (Venkatesh & Davis, 2000). As a result, both TAM2 and TAM3 used the perceived rather than actual voluntariness as a contextual variable (Venkatesh & Bala, 2008). In the proposed model, it is hypothesized that PEOU will have a direct impact on compatibility (COM) and this relationship will be stronger in the context of perceived voluntary usage of IHTs.

1.3.2.4 Organizational Context

One of the major limitations of TAM is handling the introduction of new technologies independently from the organizational dynamics (Legris, Ingham, & Collerette, 2003). Since the presenting users with new technologies would be considered as a change process, the effectiveness of the deployment of such systems depends on the interdependence between technology, the context of the organization where it is implemented, and the theoretical change model used (Orlikowski & Hoffman, 1997). Hence, any effort to expand the predictively of TAM should account for both organizational and social factors in addition to technological factors (Legris et al., 2003). This last dimension of the model was added following previous research (P. Y. K. Chau & P. J. Hu, 2002; M. P. Gagnon, Orruno, et al., 2012) to describe the impact of social, organizational and technical contexts of IHTs' implementation.

Subjective Norm

SN is a key underpinning in the TPB, and it was embraced in TAM2 and TAM3 to span the social influence process. It is defined as the "person's perception that most people who are important to him think he should or should not perform the behavior in question" (Fisbein & Ajzen, 1975, p. 302). Venkatesh and Davis (2000) argued that even when individuals do not intend to perform a behavior, they may do it merely because they think it is an expectation from a person whom they have the motivation to comply with. In the proposed model, SN is expected to have a

direct impact on PU. Nevertheless, the impact of SN on the use of technology was previously reported to be higher among women compared to men (Venkatesh & Morris, 2000; Venkatesh et al., 2000). Therefore, the relationship between SN and PU is expected to be moderated by gender.

Facilitating Conditions

According to the work by Venkatesh et al. (2003) the UTAUT, facilitating conditions (FC) described as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system." In that model, FC was considered as a predictor of actual usage rather than BIU because of the presence of effort expectancy (ease of system use and implementation) that captures organizational support infrastructure (Venkatesh et al., 2003). However, some studies reported FC as the major determinant of BIU among hospital personnel in general (Aggelidis & Chatzoglou, 2009), and consistently among healthcare professional in telemedicine in particular (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012; Orruno et al., 2011). Later research in the field of IHTs also showed FC as a significant predictor of BIU (M. P. Gagnon, Orruno, et al., 2012).

In their seminal research about the TAM3, Venkatesh and Bala (2008) proposed that the presence of FC, or external control, in the context of complex systems play a major role in influencing the determinants of PU and PEOU. Furthermore, in the context of IHTs, the presence of organizational support (e.g., helpdesk and training) was reported to alleviate the consequences of communication with patients on clinicians' workflow (Timmerman et al., 2016). Hence, FC was hypothesized in the proposed model to have a direct positive impact on compatibility of IHTs.

Reviewing the literature, FC is composed of two major components; technical that represents individual's resources and skill, and organizational that encompasses factors external to the individual (M.-P. Gagnon et al., 2003). In their proposed model about physicians' acceptance

of telemedicine, P. Y. K. Chau and P. J. Hu (2002) argued that the dominance of physicians in many healthcare organizations impacts their control of non-technological (organizational) resources and thus only technical component is more relevant and worthy to include in the model. However, since our model is designed for both physicians and non-physician clinicians (physician assistant, nurse practitioner, and nurse), the inclusion of both components, we argue, is more appropriate.

1.4 RELATED PRELIMINARY WORK

Pocket PATH Synergy is an IHT that connects patients' use of Pocket PATH: Personal Assistant for Tracking Health, a customized smartphone application with Pocket PATH Link, a web-based companion website for clinicians. In an open pilot trial study to evaluate the feasibility and the usefulness of Pocket PATH Synergy in the setting of lung transplant, 15 clinicians completed an online and anonymous survey following the trial. More than half of the clinicians reported high agreement with its ease of use, perceived usefulness, and their intention to use Pocket PATH Synergy (Figure 6). The study demonstrates the feasibility of the proposed research, the ability of the research team to successfully plan and execute this type of study, and the adequacy of mentorship and institutional support. The dissertation study expands upon the pilot work by proposing an enhanced model and a more comprehensive exploration of clinicians' intention to use IHTs to support self-management of patients with chronic cardiopulmonary diseases.

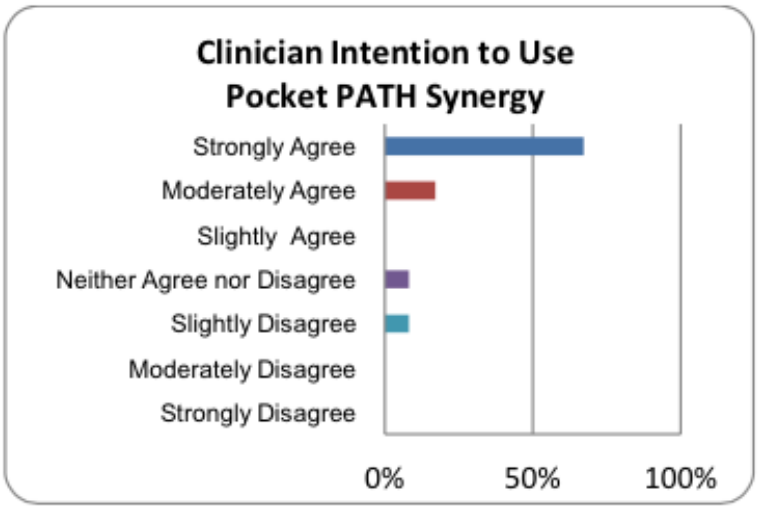

Figure 6. Relative pilot work

1.5 SIGNIFICANCE AND INNOVATION

This work is significant for the following reasons:

- It is often clinicians who make the decision about using home self-management technologies and the kind of technology needed for patients to promote self-management (P. Y. K. Chau & P. J.-H. Hu, 2002; Shah et al., 2013). The success and innovation of IHTs thus depend on the collaboration between clinicians and manufacturers designers (Chatterji et al., 2008). Accordingly, clinician's support of patient activation is vital for improvement in self-management behaviors and ultimately clinical outcomes (Judith H Hibbard, Mahoney, Stock, & Tusler, 2007). The importance of this project lies in the knowledge it provides to developers and clinician consumers of IHTs to better accommodate clinicians' practice processes and support the needs of cardiopulmonary patients. A better understanding of the dynamics behind clinicians' beliefs about using IHTs to promote self-

management for patients may lead to customization of interfaces to improve clinicians' ultimate adoption and engagement.

- The inclusion of clinicians' beliefs about patients' self-management in the model gives it a deeper dimension to tap into the special context of healthcare and IHTs. This is different from previous models that were limited to technical variables and constructs, which were mainly adopted from outside the healthcare paradigm, and assumed that all clinicians are motivated to activate patient self-management behaviors regardless of the communication mean. Hence, this study is innovative because no previous study took into consideration the level of clinicians' beliefs about self-management, or focused on clinicians' perspectives rather than those of patients.
- The use of a mixed-methods approach helps in recognizing the contextual environment that influences clinicians' intention to use IHTs. This is not possible to achieve using only a quantitative approach which dominates the literature on IHTs and is considered to be more "context-free". A qualitative approach is better suited to explore the complex and dynamic nature of the clinicians' behaviors and experiences (Grypdonck, 1997) as its inductive nature is typically more appropriate for developing and enhancing theoretical models than quantitative approaches (Sinuff, Cook, & Giacomini, 2007).
- The primary investigator has assembled a dissertation team to oversee this study that includes clinicians and IHT specialists who speak the language and understand the specific needs of healthcare providers; unlike most of the other qualitative studies on technology acceptance that took place outside the healthcare setting by non-healthcare providers. In addition, the resources available at the University of Pittsburgh will facilitate the conduct of the study. These resources include, but are not limited to, experts in chronic

cardiopulmonary disease, qualitative and mixed-methods research, statistics and IHTs who will ensure the rigor of the study. Also, this study will take advantage of the availability of an existing IHT (Pocket PATH Synergy) with simulation capabilities that can be tested by clinicians with a variety of backgrounds and experiences (physicians, nurse practitioners, and nurses).

2.0 MANUSCRIPT 1: "THE ACCEPTANCE OF INTERACTIVE HEALTH TECHNOLOGIES BY HEALTHCARE PROVIDERS TO SUPPORT PATIENT SELF-MANAGEMENT: A SYSTEMATIC REVIEW"

2.1 ABSTRACT

Given the expected large-scale adoption of interactive health technologies (IHTs) that connects patient smartphone apps to clinician portals, little is known about their adoption by clinicians. This study aimed to synthesize the literature about the factors influencing clinicians' acceptance of IHTs. Five databases were systematically searched for relevant peer-reviewed articles. Included articles were quantitative and qualitative that discussed IHTs from clinicians' perspective. Eight studies were included in this review; four quantitative (observational), three qualitative, and one mixed-methods study. The identified factors were classified according to the Unified Theory of Acceptance and Use of Technology (UTAUT) and included: performance expectancy (perceived ease of use and relative advantage), effort expectancy (perceived ease of use), social influence, and facilitating conditions. Inconsistent impact of age, experience, and profession was reported. This review underscores the need for more rigorous studies that examine the factors impacting the acceptance of IHTs.

2.2 INTRODUCTION

Chronic diseases are the leading cause of mortality, morbidity and health resource utilization in the U.S. (Centers for Disease control and Prevention, 2017; Stearns et al., 2000). Almost half of the adults in the United States are diagnosed with a chronic disease, which causes increased pressure on health services (McDermott & While, 2013). Self-management, which entails an interactive process of collaboration between patients and clinicians, assists in early detection and treatment of problems related to chronic diseases (Lorig & Holman, 2003; Schulman-Green et al., 2012).

Fortunately, patients' self-management can be supported by the use of interactive health technologies (IHTs), which are capable of providing real-time monitoring, detection of changes in health status, and the ability to deliver interventions (Kumar et al., 2013; Lanseng & Andreassen, 2007). Furthermore, IHTs facilitate patient-clinician communication by connecting patient terminals (mobile applications) to clinician web-based portals for personalized feedback (DeVito Dabbs et al., 2009; Kollmann et al., 2007). This is distinct from the broader term "mobile health (mHealth)" used in a recent systematic review that included the use of any mobile phones/ devices in the healthcare setting (M. P. Gagnon, Ngangue, Payne-Gagnon, & Desmartis, 2016). While other technologies may have some features of IHTs (e.g. stand-alone mobile apps, remote monitoring), they are not expected to lead to fundamental changes in healthcare practices as IHTs impact both the clinicians' workflow and patient level of engagement in own self-management (De Vito Dabbs et al., 2009; de Vries et al., 2017). In fact, the term IHTs is similar to "interactive telemedicine" that was used by a recent Cochrane systematic review to describe the technologies in which health professionals respond to the transmission of information from a patient (Flodgren et al., 2015). For the purpose of this review, we will use the term IHTs to refer to clinicians' usage

of web portals to review data and communicate with patients who share their health data remotely to clinicians via mobile apps.

Despite their expected benefits, the implementation and acceptance of health technology, including IHTs, face many barriers (Boonstra & Broekhuis, 2010). One barrier that plays a major role in the relatively slow development of health information technology is the unexpected consequences of technology use on users' reactions, including both patients and clinicians (Holden & Karsh, 2010). The active involvement of healthcare providers plays a major role in the success of any IHT for three reasons: 1) it is health professionals who make the decision about using home self-management technologies and the type needed (P. Y. K. Chau & P. J.-H. Hu, 2002; Kim et al., 2014; Shah et al., 2013); 2) the success and innovation of any of the chosen technologies depends on the collaboration between clinicians and manufacturers designers (Chatterji et al., 2008); 3) clinician's support of patient activation is vital for improvement in self-management behaviors and ultimately clinical outcomes (de Vries et al., 2017; Judith H Hibbard et al., 2007; Timmerman et al., 2016). The majority of the research studies in the literature focus on the patients' side and their acceptance of IHTs when caring for themselves, while there is a lack of studies from the perspective of the healthcare providers. The purpose of this systematic review was to investigate the factors that affect clinicians' adoption of IHTs that support patient self-management.

2.3 METHODS

2.3.1 Search Strategies

A full literature search was conducted in PubMed MEDLINE, Ovid PsycINFO, EBSCOhost CINAHL, and EMBASE for relevant article up to August 2017. We used the following search criteria to identify articles related to IHTs and their adoption by clinicians. For instance, for the PubMed, the MeSH terms "Cellular Phone" and "Attitude to Computers" were used with the terms “smartphone*”, “smart-phone*”, “smart phone*”, “iPhone”, “Android”, “blackberry”, "black berry", "Windows Mobile", “Adoption”, “Acceptance”, "intention to use", “attitude toward using”, "user satisfaction", “TAM”, “TAM2”, and “UTAUT”. The PsycINFO database was searched using various combinations of subject headings and terms that included "cellular telephones", "cellular phones", "cellular phones", "clinicians", "health personnel attitudes", and "telemedicine". The filter options in both databases were set to include only articles published in English. Similar search criteria were used with the CINAHL and EMBASE databases. References in the fully retrieved articles were reviewed for any possible studies that met our inclusion criteria. In addition, Google Scholar was used to find studies citing our eligible articles to identify any additional relevant reports that could not be found in the initial search. The final search yielded citations from all the databases were imported into Endnote (version 8.1) citation manager and duplicate records were filtered out.

2.3.2 Inclusion and Exclusion Criteria

The Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guided this review (Moher, Liberati, Tetzlaff, & Altman, 2009). The current review addressed only IHTs as they are different from b . Articles were included if they: 1) discussed patient-clinician interaction using IHTs; 2) reported clinicians' perceptions about the technology being used; 3) were based on empirical design (quantitative, qualitative, or mixed-methods); and 4) were published in English. Articles were excluded if they: 1) only focused on patients' perspectives about IHTs, 2) covered the general usage of mHealth in its broader term but not the patient-clinician interaction via IHTs, or 3) was a review article. Because of the limited number of studies that met our inclusion criteria, no restrictions were made on the design or sample size.

2.3.3 Data Extraction for Review

All database searches, article retrievals, and analysis of results were performed by the primary investigator of this study (MA). A faculty-librarian was consulted during the generation of PubMed search syntax. Each article was screened by two reviewers, and if any discrepancies occurred, discussion was performed to reach out a consensus about including the article in the review or not. The screening process is reported in Figure 7. For each article included in the final analysis, key information was extracted including the first author, year, sample size, the theory used, dependent variable(s), direct independent variables, and variance explained of the dependent variable (if any).

In this review, we reported the study, research design, participants, technology implemented or developed, theory used, and the key findings. For the quantitative articles included in this review, the coefficients of determination (R^2) were reported to represent the variance explained by the predictors. In case of logistic regression was used instead of linear regression, pseudo- R^2 was reported. Findings only relevant to clinicians were included in this review for the articles that reported both patients and clinicians' perspectives.

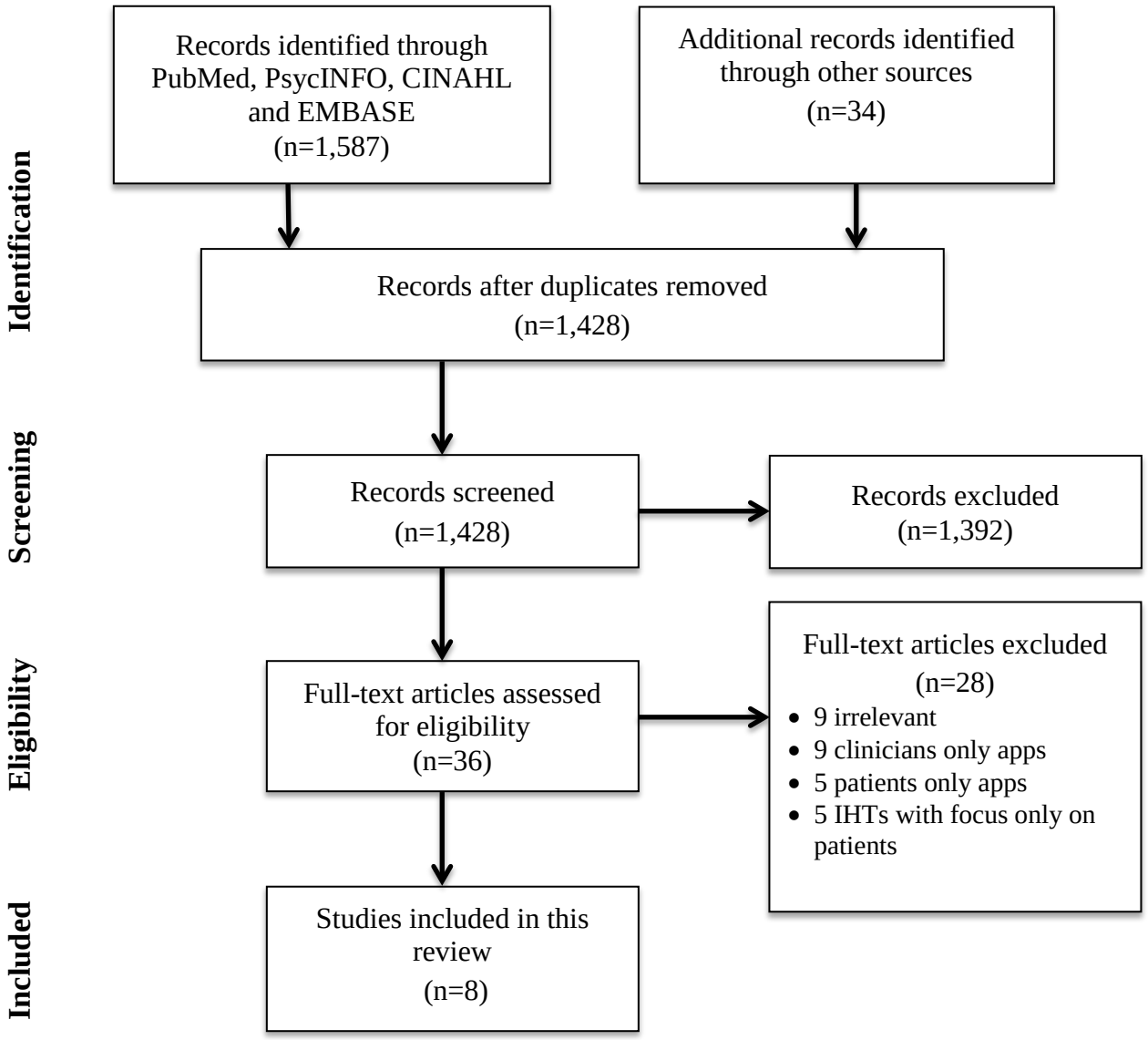

Figure 7. Systematic review process for clinicians' perceptions about IHTs for patient self-management guided by the PRISMA statement

2.3.4 Data Analysis and Synthesis

In addition to the extracted information, a scoring system by Pluye et al was used to appraise the quality of the included studies (Pluye, Gagnon, Griffiths, & Johnson-Lafleur, 2009). The criteria are designed to evaluate the methodological quality of qualitative, quantitative and mixed methods studies on a percentage score between 0 and 100. The score is calculated by dividing the number of present positive criteria in the study over the maximum possible positive items, and then multiplied by 100. Accordingly, the higher the score, the better the quality of the study.

Following a similar approach to the systematic review by Li, Talaei-Khoei, Seale, Ray, and Macintyre (2013), data were analyzed by extracting the factors that impacted the adoption of IHTs, and then they were clustered according to the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). The UTAUT was chosen as a framework for synthesis in this review because of its high explanatory performance of technology adoption and its wide coverage of a variety of factors from different theories. The theory adopts three constructs as the determinants of intention to use including *performance expectancy, effort expectancy,* and *social influence*. While the fourth construct, *facilitating conditions*, was viewed as a determinant of the use behavior, it was used in this review as a factor to explain variability in the intention to use IHTs.

2.4 RESULTS

2.4.1 Search Results

A total of 1,428 records (titles and abstracts) were identified after removing the duplicates; the full-text was obtained for 36 articles for detailed full-text evaluation. Out of those, 28 records were excluded because they did not meet the inclusion criteria and only 8 articles were included in this review (Figure 7).

2.4.2 Characteristics of the Included Studies

The characteristics of the included studies are summarized in Table 1. The studies were published between 2012 and 2017 and each of them took place in a single or sometimes multiple countries including the United States, United Kingdom, Netherlands, Spain, China, Taiwan, and Japan. Participants in the included studies were physicians, general practitioners, nurse practitioners, pharmacists, nurses and other healthcare professionals (for instance pediatricians and physiotherapists).

Half the studies used quantitative and correlational descriptive design by surveying the clinicians (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012; Kuhn et al., 2014; Okazaki et al., 2012), three publications were qualitative (de Vries et al., 2017; Schulte et al., 2016; Timmerman et al., 2016), and one was a mixed methods study – though the data from clinicians were only qualitative (Verwey et al., 2014). The quality score for the included study ranged from 67% -100%. The theoretical frameworks used in these studies included DeLone and McLean Information System (IS) Success Model (Okazaki et al., 2012), the Diffusion of Innovation Theory (Kuhn et al., 2014;

Schulte et al., 2016), and its derivatives the technology acceptance model (TAM) (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (de Vries et al., 2017; Timmerman et al., 2016).

Table 1. Articles on determinants of clinicians' acceptance of IHTs

• ***Study*** • ***Country***	• ***Design*** • ***Participants***	• ***Technology*** • ***Theory***	• ***Key Findings***	• ***Quality Score***
(Asua et al., 2012) Spain	• Observational (survey) • N= 268 (nurses, general practitioners, pediatricians)	• Tele-monitoring system where clinicians receive data from patients with cardiopulmonary disorders about respiratory rate, heart rate, blood pressure, oxygen saturation, weight and body temperature • A modified version of the Technology Acceptance Model (TAM)	• PU → BIU: (p=.02) • PEOU → BIU: (p=.28) • COM → BIU: (p=.01) • SN → BIU: (p=.85) • Facilitator → BIU: (<.001) • Habit → BIU: (p=.23) • Nagelkerke R^2: 0.72	• 67%
(de Vries et al., 2017) Netherlands, Spain and the United Kingdom	• Qualitative, multi-country study (focus groups and face-to-face interviews) • N=21 (pharmacists, pediatricians, general practitioners, internists, practice nurses and professionals caring for patients with a rare disease).	• The development of Web-Recognizing Adverse Drug Reactions (Web-RADR), a two-way communication app between patients and healthcare providers • Thematic analysis was conducted and arranged according to The Unified Theory of Acceptance and	• Influencing factors for using the app: o Relative advantage: feedback, storage of reports, and other functions of the app (e.g. prediction models for Adverse Drug Reactions) o Effort expectancy: ease of use, type of language used in the app	• 83%

• ***Study*** • ***Country***	• ***Design*** • ***Participants***	• ***Technology*** • ***Theory***	• ***Key Findings***	• ***Quality Score***
	The findings are mixed with patients' feedback	Use of Technology (UTAUT)	o Social influence: the prestige of the authority (the organization or the clinician) behind the app o Facilitating conditions: the source of safety information provided through the app, security of the app, layout, the operating systems on which the app can be used and the costs	
(M. P. Gagnon, Orruno, et al., 2012) Spain	• Observational (survey) • N= 93 (nurses, general practitioners, pediatricians)	• Home telemonitoring intervention for clinicians to receive data (respiratory rate, heart rate, blood pressure, oxygen saturation, weight, and body temperature twice a day) from patients with heart failure and/or COPD • A modified version of the Technology Acceptance Model (TAM)	• PU → BIU: (p=.59) • PEOU → BIU: (p=.67) • COM → BIU: (p=.5) • SN → BIU: (p=.16) • Facilitator → BIU: (p=.01) • Nagelkerke R^2: 0.72	•
(Kuhn et al., 2014) United States	• Observational (web-based survey)	• Description of "PE Coach", a patient-facing smartphone app designed for	• Age → BIU: (p>.05) • Early adopter → BIU: (p>.05)	• 67%

• ***Study*** • ***Country***	• ***Design*** • ***Participants***	• ***Technology*** • ***Theory***	• ***Key Findings***	• ***Quality Score***
	• N=163 (VA mental health clinicians)	prolonged exposure therapy for patients with posttraumatic stress disorder (before the app release) • Diffusion of innovations theory	• COM → BIU: (p>.05) • Smartphone ownership → BIU: (p<.001) • Relative advantage → BIU: (p<.001) • Complexity → BIU: (p<.05) • R^2 = 0.62	
(Okazaki et al., 2012**)** Japan	• Observational (web-based survey) • N= 471 (physicians)	• Graphical description of a mobile-based self-monitoring system for blood glucose, weight, physical activity, diet, insulin and medication, and blood pressure • The updated DeLone and McLean Information System (IS) Success Model	• Overall quality → BIU: (p<.15) • Net benefits → BIU: (p<.001) • Perceived value → BIU: (p<.001) • Subjective norms → BIU: (p<.001) • Privacy and security risk → BIU: (p<.22) • R^2 = 0.67	• 67%
(Schulte et al., 2016) China, Taiwan, and United States	• Qualitative (a series of focus groups) • N= 22 (Methadone maintenance treatment service providers). The findings are mixed with patients' feedback	• Development phase of a smartphone application (S-Health) to support recovery, self-care and medication adherence among opioid-dependent patients • Data were analyzed based on the Diffusion of Innovation (DOI) theory	• Three of the DOI factors impacted the smartphone application acceptance o Relative Advantage: overcome logistical barriers, and supplement limited services in China and Taiwan o Compatibility: aids in meeting recovery needs	• 67%

• ***Study*** • ***Country***	• ***Design*** • ***Participants***	• ***Technology*** • ***Theory***	• ***Key Findings***	• ***Quality Score***
			and goals, but in China and Taiwan, not during strong craving phase o Complexity: concerns about smartphone access and familiarity, individualization of content, and privacy and security (especially in China and Taiwan)	
(Timmerman et al., 2016) Netherlands	• Qualitative (semi-structured interviews, focus groups, and scenario evaluations) • N= 6, 5, and 5 healthcare providers (HCP) for semi-structured interviews, focus groups, and scenario evaluations, respectively (thoracic surgeon, pulmonologist, physiotherapists, pulmonary rehabilitation specialists, and nurse practitioner)	• The development phase of an app for lung cancer patients treated with lung resection and their healthcare providers • The Unified Theory of Acceptance and Use of Technology (UTAUT) to analyze the for semi-structured interviews, focus groups	• Semi-structured interviews: o Benefits: improve current care and patient-HCP communication, collect information about patient life style, ambulant monitoring, and provide tailored web-based exercise program o Concerns: unlike nurse practitioners and physiotherapist, physicians worried that the cost and time of communication with patients will outweigh the added value of the app. HCPs	• 100%

• ***Study*** • ***Country***	• ***Design*** • ***Participants***	• ***Technology*** • ***Theory***	• ***Key Findings***	• ***Quality Score***
			reported the limited time for patient consultations and the need to integrate the app into the EMR. • Focus groups: the importance of modular and scalable app that allows adjustment for groups of patients.	
(Verwey et al., 2014) Netherlands	• Mixed-methods, but clinicians provided only qualitative data. • N=3 nurses	• The testing of a tool that consisted of a smartphone app and an accelerometer connected to nurse's website • No theory was used.	• Nurses valued the collection of objective data about patient activity, the positive reaction of patients to reach their goals, and the ease of reviewing the facilitators and barriers to physical activity with patients • Concerns about receiving too many communications from patients, and spending too much time explaining the tool to patients	• 67%

2.4.3 Factors Impacting the Adoption of IHTs

2.4.3.1 Clinician Characteristics

In general, no significant differences between physicians and nurses with regards to intention to use IHTs (Asua et al., 2012) or between different physician specialties (Okazaki et al., 2012). Nevertheless, physicians showed negative attitudes toward the use of the online communication with patients due to concerns about the time and money (Timmerman et al., 2016).

Younger age (<40) (Kuhn et al., 2014; Okazaki et al., 2012), smartphone ownership, and experience using IHTs (Kuhn et al., 2014) were found to be related to more favorable perceptions about IHTs. However, other studies reported no difference between clinicians with age, education level (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012), number of years in clinical practice, and previous experience with using IHTs (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012; Okazaki et al., 2012).

2.4.3.2 Performance Expectancy

Perceived usefulness describes how a clinician believes that the use of an IHT will enhance their job performance (F.D. Davis, 1989), whether it is a clinical job or not (Li et al., 2013). It was found that perceived usefulness is a major determinant of intention to use IHTs (Asua et al., 2012), however, it turned out to not to be a significant predictor of intention to use when other variables were considered in the model (M. P. Gagnon, Orruno, et al., 2012). Clinicians also reported that IHTs are useful to communicate with patients and organize their information (Timmerman et al., 2016; Verwey et al., 2014), provide better access to care for patients with limited services (Schulte et al., 2016), and have enhanced functionality, efficiency, productivity, and practicality in their job performance (Okazaki et al., 2012).

Relative advantage is the degree to which the use of IHTs is perceived as superior to the precursor practices (Venkatesh et al., 2003). Three studies reported the relative advantage as one of the factors for adopting IHTs (de Vries et al., 2017; Kuhn et al., 2014; Schulte et al., 2016), and the other studies implicitly reported the added value of IHTs in improving current care and patient-clinician communication, collecting information about patient lifestyle (Timmerman et al., 2016; Verwey et al., 2014), and overcoming logistic barriers to improve patients' control over their health and health outcomes (Okazaki et al., 2012; Schulte et al., 2016; Verwey et al., 2014).

2.4.3.3 Effort Expectancy

Clinicians did not consider *perceived ease of use,* the degree to which the use of technology is considered to be free of effort (F.D. Davis, 1989; Venkatesh et al., 2003), as a key determinant in their intention to use IHTs (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012). However, clinicians reported their concerns about the complexity of using IHTs, especially from the side of their patients, because of the language used and the familiarity with using the app or smartphones in general (de Vries et al., 2017; Schulte et al., 2016). In fact, clinicians were worried about spending too much time explaining the IHTs to their patients than the clinical counseling itself (Verwey et al., 2014).

2.4.3.4 Social Influence

The social influence of the work culture is captured by the concept of *subjective norm,* which defines clinicians' perception about the adoption of IHTs by most people in their organization (Venkatesh & Davis, 2000). Three articles examined the impact of subjective norms on clinicians' intention to use IHTs. When examined at the presence of other factors, subjective norms had no significant impact on intention to use IHTs (Asua et al., 2012; M. P. Gagnon, Orruno,

et al., 2012); however, the other study reported a significant impact of subjective norms (Okazaki et al., 2012). In addition, the prestige and thus the credibility of the organization or the clinician behind the IHT was viewed as a factor to its wider adoption (de Vries et al., 2017).

2.4.3.5 Facilitating Conditions

Clinicians voiced their concerns about receiving too many communications from patients about technical issues regarding IHTs (Verwey et al., 2014). The availability of helpdesk was requested as one of the main support features for an adoptable IHT form clinicians' perspective (Timmerman et al., 2016). In addition, clinicians were worried about the lack of time available for patient visits especially if they have to log in to another system in addition to the already implemented electronic medical records (Timmerman et al., 2016). Physicians were concerned more than other clinicians that the time consumed in the two-way contact with their patients would outweigh the added value of the IHT (de Vries et al., 2017; Timmerman et al., 2016). Clinicians also mentioned concerns about the privacy and security and of patients' data when stored on patient phones or shared via IHTs (de Vries et al., 2017; Schulte et al., 2016).

2.5 DISCUSSION

To the best of our knowledge, this is the only systematic review to summarize the evidence about the factors in relation to clinicians' adoption of IHTs to support patient self-management. Distinct from other automated technologies, IHTs require patients' and clinicians' interaction and thus they have unique consequences on clinical management and workflow. Therefore, the results from the review are limited to IHTs and should not be generalized to the use of similar technologies

that are more common (e.g., remote monitoring apps). All the eight articles included in this review were published within the last five years, which indicates the increase in the use and development of IHTs and the inclusion of clinicians as fundamental stakeholders.

Similar to studies conducted in other fields, the concept of perceived usefulness has been consistently reported as the significant determinant of behavioral intention to use in technology acceptance research (Or & Karsh, 2009; Venkatesh & Davis, 2000). Only one study in this review (M. P. Gagnon, Orruno, et al., 2012) reported no significant impact of perceived usefulness when entered in the same analysis model with facilitating conditions. However, this should be interpreted in the context of that study and the setting where it was conducted. It seems that workplaces where organizational support is an expectation tend to have less impact of facilitating conditions.

This review emphasizes the importance of interpreting the results about IHT acceptance with caution to the absence of understanding the social context and values of the community. Some of the discrepancies in the results between some of the studies might be attributed to the cultural differences between the different countries where the studies were conducted. For instance, as previously reported in cultural-comparative innovation acceptance studies, subjective norms and interpersonal relationships plays a significant role among individuals in Japan, but not in Western cultures where the emphasis is more on individual values (Ando, Yorifuji, Ohnuma, Matthies, & Kanbara, 2015; Hirose & Tabe, 2016; Straub & Keil, 1997). Hence, it is not unexpected to see a significant impact of subjective norms on Japanese clinicians' intention to use IHTs (Okazaki et al., 2012) when compared to their counterparts in Spain (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012).

Several limitations are acknowledged in this review. Gray literature such as unpublished dissertation works and articles published in languages other than English were not included, which

limited our sources of data for the present study. In addition, we expect that some qualitative description about clinicians' adoption is mentioned in body of some published articles but not in their titles or abstracts. Therefore, some information might have been overlooked during the initial screening process where the titles and abstracts were used to screen articles for eligibility to be included in this review.

2.6 CONCLUSIONS

In general, ongoing research shows that TAM and other relative models (e.g. UTAUT) have a high capacity of predicting the acceptance of technology. Although such models did a decent job in predicting and explaining end-user's acceptance of IHTs, they are still susceptible for more enhancements. The refinement and contextualization of theoretical models about technology acceptance enhance their prediction capability and improve their explanatory power. This opens the door for future research and the introductions of more comprehensive theories. Besides, it will guide the development of future training courses and the design and development of more user-friendly technologies. The advancement in research conducted on IHTs will be reflected as an improvement in daily clinical and administrative aspects, an endeavor to enhance patient quality of life and health outcomes.

3.0 METHODS

3.1 STUDY DESIGN

This mixed-methods study (Creswell, Klassen, Plano Clark, & Smith, 2011) was comprised of three phases using explanatory sequential design (QUAN>qual) (Fetters, Curry, & Creswell, 2013; Sandelowski, 2000). In phase I, a quantitative, a cross-sectional and correlational design was used to evaluate the professional, technological, and organizational factors purported to influence clinicians' intention to use IHTs to support patient self-management (Aim 2). In phase II, a qualitative descriptive design was used to further explain the factors that influence clinicians' beliefs about using IHTs to promote self-management (Aim 3). In Phase III, both the quantitative and qualitative inquiries were integrated to provide a comprehensive picture about clinician's adoption of IHTs (Aim 4).

The "added variable" approach proposed in the quantitative portion of the study was used to identify the strength and significance of the relationships purported in the model. However, alone it is insufficient to develop theories for new niche fields such as IHTs. More in-depth research designs, such as mixed methods, are helpful in approaching the complex phenomena of healthcare from different perspectives recognizing the contextual environmental influences for the intention to use IHTs. This understanding is not possible to achieve using only the dominant quantitative approach in the literature of IHTs, which is considered to be more "context-free". Qualitative approaches are often better suited to explore the complex and dynamic nature of clinicians' behaviors and experiences (Grypdonck, 1997) as they are more appropriate for developing and enhancing theoretical models than quantitative approaches (Sinuff et al., 2007). In

this study, the qualitative data helped in providing a further explanation (Sandelowski, 2000) of the clinicians' survey responses about the factors in the conceptual model. The use of mixed-methods design to explore clinicians' beliefs about IHTs provided a deeper understanding of the phenomenon of clinicians' beliefs about IHTs and their complex social, technological, and cultural nature (Bossen, Jensen, & Udsen, 2013; Scott & Briggs, 2009).

3.2 QUANTITATIVE PHASE

3.2.1 Sample and Setting

This study recruited clinicians involved in the care of patients with chronic cardiac or pulmonary diseases (heart and lung failure or transplant recipients) at the University of Pittsburgh Medical Center (UPMC). This setting was selected because UPMC is one of the leading hospital systems in the US involved in care for patients with chronic cardiac and pulmonary diseases, and has one of the largest heart and lung transplant programs in the world (Department of Health and Human Services, 2012; UPMC, 2013). Clinicians in the cardiac and pulmonary departments (medical and surgical) treating patients with end-stage heart or lung failure or transplant were approached to participate in the study. Clinicians targeted in this study include physicians (intern, attendant, resident), advanced practitioners (nurse practitioner, transplant coordinator, physician assistant), registered nurses and care coordinators who are capable of performing follow-up on patient care (e.g. cardiac rehabilitation registered nurses).

3.2.2 Measures

The full on-line survey is included in Appendix A.

3.2.2.1 Socio-Demographics

These were measured using an investigator-developed profile of sample characteristics that included age (years), gender (male vs. female), and education level (associate's degree, bachelor's degree, master's degree, doctorate / terminal degree).

3.2.2.2 Moderator Variables

Profession

This was used to obtain data about the professional affiliation of the clinician including physicians, nurse practitioners, physician assistants, transplant/ care coordinators or registered nurses.

Experience (EXP)

This was measured by answering one investigator-developed question about the years of experience in usage of IHTs, which gives an indication about participants' computer literacy of using information technologies in following up on patinet generated data.

Voluntariness (VOL)

Expected perceived voluntariness of the system usage was captured using three items of a 7-point Likert-type ("strongly disagree" to "strongly agree"). This scale was adopted from TAM3,

and was previously reported to be valid and have an acceptable internal consistency reliability (Cronbach's $\alpha > 0.7$) (Venkatesh & Bala, 2008).

3.2.2.3 Independent Variables

Professional Context

Clinicians' Beliefs about Patient Self-Management (CBSM)

The CBSM variable was measured using the short the Clinician Support for Patient Activation Measure (CS-PAM) (J. H. Hibbard et al., 2010). The scale uses the modified 13-items of a 4-point Likert-type that ranges from "not at all important" to "very important". The CS-PAM was found to have acceptable internal consistency reliability (Cronbach's $\alpha = 0.82$-0.97) and able to differentiate clinicians from different countries based on their level of beliefs and attitudes towards patient activation and self-management (J. H. Hibbard et al., 2010; NHS England, 2015; Rademakers, Jansen, van der Hoek, & Heijmans, 2015; Stoilkova-Hartmann, Janssen, Franssen, Spruit, & Wouters, 2015). The CS-PAM was licensed and scaled for this study by the developer, Insignia Health, University of Oregon, United States (Insignia Health, 2010).

Compatibility (COM)

The measure for this variable was adopted from the UTAUT, and it uses three-items of a 7-point Likert-type that ranges from "strongly disagree" to "strongly agree" (Venkatesh et al., 2003). This scale was able to capture clinicians' resistance to change their routine in response to stress created by using new technology (M.-P. Gagnon et al., 2013; Jung & Loria, 2010; Venkatesh et al., 2000; Ye, 2008), and it was previously reported to have adequate validity and internal

consistency reliability (Cronbach's $\alpha > 0.8$) (Chau & Hu, 2001; Putzer & Park, 2010; Tung, Chang, & Chou, 2008; Venkatesh et al., 2003; Wu et al., 2007).

Technological Context

Perceived Usefulness (PU)

This variable was measured using four items of a 7-point Likert-type ("strongly disagree" to "strongly agree"). The PU is at the core of the TAM, TAM2, and TAM3 models, and it was consistently reported as valid and reliable measure (Cronbach' α range between 0.87 and 0.98). (F.D. Davis, 1989; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000).

Perceived Ease of Use (PEOU)

Similar to PU, PEOU was measured using four items of a 7-point Likert-type that ranges from "strongly disagree" to "strongly agree". The scale was previously reported as valid and reliable measure with a Cronbach's α that ranges between 0.86 and 0.98 (F.D. Davis, 1989; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000).

Organizational Context

Subjective Norms (SN)

This variable was measured using a scale of four items of a 7-point Likert-type that ranges from "strongly disagree" to "strongly agree". The scale, which was adopted from TAM2 and TAM3, captures the informal organizational influence in the clinicians' work setting, and it was found to be valid and reliable (Cronbach's α ranges between 0.83 and 0.86) (Venkatesh & Bala, 2008).

Facilitating Conditions (FC)

The measure for FC was chosen to represent the formal organizational support and influences in the clinicians' work setting. This measure included three items that represent the organizational and technical components (Cronbach's alpha ranged from 0.83 to 0.87) (Venkatesh et al., 2003). All the items followed a 7-point Likert-type that ranges from "strongly disagree" to "strongly agree".

3.2.2.4 Dependent Variable

Behavioral Intention to Use (IU)

Clinicians were asked to record their perception regarding the likelihood of their intention to use IHTs in response to 3 items of a 7-point Likert type ("strongly disagree" to "strongly agree") (Venkatesh & Bala, 2008). Previous work showed that this measure has internal consistency reliability (Cronbach's alpha) that ranges between 0.88 and 0.91 (Venkatesh & Bala, 2008).

3.2.3 Data Collection Procedure

All clinicians in the cardiac and pulmonary departments (medical and surgical) treating patients with end-stage heart or lung failure or transplant were approached via e-mail for possible study participation, a process that was facilitated by the medical directors of their departments. Follow-up reminder emails were sent out 1–2 weeks after the initial invitation to increase the response rates.

The online survey was developed and distributed via Qualtrics® survey software (Qualtrics LLC, Provo UT), and it was emailed to participants for completion in one session (~ 20 minutes).

To minimize the missing data, a warning message about the missed questions shows before the user submit the questionnaire. The option of users saving their answers and complete later was available given that they use the same invitation link to access the saved questionnaire (Qualtrics LLC, 2016). Prior to actual use, the survey was pilot tested for clarity with at least one clinician who is not eligible for the study and modified as needed.

The survey included five sections (pages) that were presented to participants in the following order. At first, socio-demographics were collected at the beginning of the survey. Then, the CBSM variable was measured using the Clinician Support for Patient Activation Measure (CS-PAM) (J. H. Hibbard et al., 2010). The scale uses the modified 13-items of a 4-point Likert-type that ranges from "not at all important" to "very important". The CS-PAM was evaluated in the first half of the survey to measure the bare CBSM to avoid contaminating their perspectives with the next step in which an example of IHT (Pocket PATH Synergy) was introduced using simulation (illustrative voice over-video). The video, which includes subtitles in case access to speakers is not available, guided the clinician through an objective description of features and functions of Pocket PATH Synergy including both the patient smartphone application and the clinicians' web-portal. An option to view static screenshots and the software description was available should the participant was unable to access the video on their device. The approach of providing a description of the sample IHT before surveying clinicians' intention to use is not uncommon in the literature (Kuhn et al., 2014; Okazaki et al., 2012). Finally, a list of 7-point Likert-type questions was used to measure the rest of the variables in the research model including PU, PEOU, COM, SN, FC, VOL, and BIU.

3.2.4 Statistical Analysis

3.2.4.1 Sample Size Justification

Hair, Ringle, and Sarstedt (2011) reported that the minimum sample size should be at least ten times the largest number of indicators to measure one construct and at least ten times the largest number of predictors for one latent variable. Following such criteria, a sample size of 40 clinicians was required to have enough power to test our conceptual model with four direct predictors of BIU and a maximum of four indicators per measure.

3.2.4.2 Descriptive Statistics

All the variables in our model are considered to have ordinal level of measurement. Despite the fact that such Likert-scale variables are not considered continuous, they can be taken to be interval scales and thus they are subject to descriptive statistics of continuous variables (Brown, 2011). Therefore, these variables were summarized using mean and standard deviation, or median and inter-quartile range depending on the normality of the variable distribution. Categorical variables of sample characteristics (gender, education, profession and specialty) were described using frequencies and percentages.

3.2.4.3 Screening Data for Outliers

Data were thoroughly checked for the accuracy through proofreading and the computation of appropriate descriptive statistics. Ranges were calculated for continuous variables to ensure that there are no outliers due to data entry errors. Univariate outliers were calculated for categorical variables using frequencies to ensure that there are no categories with less than 10% of cases. Univariate outliers for continuous variables were checked using histograms and boxplots. Cases

for values identified as univariate outliers were further checked to see if they are multivariate outliers using Mahalanobis distance, which describes the distance of a case from the centroid. Multivariate outlier cases were deleted unless they are found part of the population.

3.2.4.4 Missing Data Considerations

We expected missing data since the survey questions were not mandatory for participants to fill, and the users were offered the option to save the survey and continue in a later time. If some items are found to be incomplete due to partial completion of the survey, the participants were contacted via e-mail to finish and submit the survey. If for any reason the participants with incomplete questionnaires can not be reached, the amount and pattern of missing data for each case and for each variable were described using frequencies and percentages. Little's test was used to investigate if the data are missing completely at random (MCAR). Complete case analysis or median imputation using other items of the score for that participant were used to solve for missing values.

3.2.4.5 Assessment of Underlying Assumptions

Graphs (histograms, Q-Q plots) were used to depict the distribution of the continuous variables, particularly the dependent variable, to determine the presence of anomalies from normal distribution. Measures of skewness and kurtosis were calculated to identify the variables departing from normality. Additionally, formal normality tests (e.g., Shapiro-Wilk and Kolmogorov–Smirnov tests) were performed. Data transformation was used in the absence of normal distribution. Square root method was used to transform variables with mild to moderate skewness, and log 10 method to transform highly skewed variables. Observations were assumed to be independent because the values for one case are unrelated to other cases. Linearity and

homoscedasticity were assessed using scatter plots of the dependent variable against each of the predictors. To resolve any nonlinearity, transformation of the target predictor, as described above, were done first. If this method did not improve linearity, terms with higher power of the variable were included to fit the distribution (i.e. quadratic and cubic). Breusch-Pagan test were conducted to check for homoscedasticity and if detected, variance-stabilizing transformations were performed. Finally, multicollinearity and singularity were assessed using variance inflation factor (VIF) and correlation matrix of predictors. If the VIF or any correlation between any two variables exceeds 10 and .9, respectively, the issue was resolved by dropping one of the two variables or combining them by creating a composite variable if theoretically sound.

3.2.4.6 Assessment of Psychometric Properties of Measures

The sampling adequacy was assessed using the Kaiser-Meyer-Olkin (KMO) statistic and Bartlett's sphericity test. In order to proceed with the psychometric analysis, the KMO should be at least .6 and the Bartlett's test should be significant (Hutcheson & Sofroniou, 1999). Cronbach's alpha was used to measure the internal consistency reliability of each subscale used in the survey. In order for the instrument to be reliable, the Cronbach's alpha should greater than or equal to 0.7 (Nunnally, 1978). Construct validity of the instruments was measured by testing convergent and discriminant validity using both inter-item correlation matrix and principal component analysis (Hu et al., 1999). In the correlation matrix, the items associated with a proposed factor (component) should correlate more highly with each other (convergent validity) than with items associated with other factors (discriminant validity) (Ngai, Poon, & Chan, 2007).

3.2.4.7 Specific Aim Analysis

Aim 2. Quantitatively evaluate a proposed conceptual model to explain the influence of professional, technological, and organizational factors on clinicians' intention to use IHTs for patient self-management.

The research model was fitted and tested using partial least squares - structural equation modeling PLS-SEM) as applied in SmartPLS 3.2.7 (Ringle, Wende, & Becker, 2015). The PLS-SEM method is preferred over the traditional covariance-based SEM because 1) the aim of this study is to explore and extend an existing theory, and 2) the expected small sample size (Hair et al., 2011; Jörskog & Wold, 1982). All statistical tests were 2-sided, and $p< 0.05$ was used as level of significance.

The reflective (latent) constructs were evaluated for reliability using the internal consistency reliability (Cronbach's alpha), rho_A, and composite reliability measures. For a construct to be reliable, each of these measures should be >.7 (Hair Jr, Hult, Ringle, & Sarstedt, 2017; Nunnally, 1978). In addition, factor outer loadings and the average variance extracted (AVE) were used to assess the convergent validity of the constructs. The outer loading for each of the constructs should be at least 0.7 to be considered as good, while the AVE should exceed 0.5 to be acceptable (Hair Jr et al., 2017). The discriminant validity was assessed using factor loadings, Fornell-Larcker Criterion (Fornell & Larcker, 1981), and the Heterotrait-Monotrait Ratio (HTMT) (Henseler, Ringle, & Sarstedt, 2014). Fornell and Larcker (1981) showed that the variance shared between items within the same construct should exceed the variance shared with any other construct. However, for the HTMT, the values below 0.90 express discriminant validity between the two constructs (Henseler et al., 2014).

Stone-Geisser Q^2 (cross-validated redundancy) was used to evaluate the predictive relevance of the model using the blindfolding procedure. (Hair Jr et al., 2017; Stone, 1974). A Q^2 larger than zero for any dependent construct indicates that the model has a predictive relevance for that construct (Hair Jr et al., 2017). The PLS-SEM analysis was conducted after that using the bootstrap procedure with 10,000 resamples to evaluate the model's inferential statistics. The moderation effects of age (<45 years vs. $\geq$ 45 years, gender (male vs. female), profession (physician vs. non-physician) and voluntariness (voluntary vs. involuntary) were evaluated. The voluntariness construct was dichotomized based on the median (13) of the sum score to differentiate the subjects based on their expectations of how voluntary the implementation of IHTs will be at their workplace.

3.3 QUALITATIVE PHASE

3.3.1 Sample

Approximately 6-10 clinicians from phase I were identified through purposive, criterion sampling to achieve a sample of participants who represented a range of values for the study factors. Criterion sampling, a kind of purposive sampling, uses values for preconceived measures or scores to initiate the sampling strategy (Sandelowski, 2000). According to Sandelowski (2000), participants can be selected because they represent average scores (typical case sampling), intense scores (intensity sampling), or extreme scores (extreme or deviant case sampling). Sandelowski also proposes that criterion sampling can be used to triangulate the accuracy of the quantitative scores by combining different data collection techniques, and/ or to complement the quantitative

sections and explain what makes the scores as they are (typical, intense, or extreme). In this study, participants' intense scores (upper and lower quartiles) were used for each of the professional, technological, and organizational contexts, in addition to representatives from each of the professional affiliations (i.e. physician, physician assistant, nurse practitioner, and nurse) and gender as criterion to achieve a sample that exemplifies variant clinicians' perspectives and characteristics.

3.3.2 Data Collection

Semi-structured interviews including closed and open-ended questions were used (Appendix B). Prior to actual use, the drafted interview script was pilot tested for clarity with at least one clinician who is not eligible for the study and modified as needed. The use of semi-structured interviews and open-ended questions encourages participants to express their perspectives (Barriball & While, 1994) about the adoption of IHTs in their practice to support patient self-management. One-on-one interviews took place in a private room, typically the clinician's office or conference room adjacent to the clinical space based on the convenience of the participant. With the participant's permission interviews were audiotaped and an assistant will take notes and make observations during the interview. Participants were assured the interested is in discussing their perceptions; there are no right or wrong responses and no judgments to be made. The interviews lasted about 25-50 minutes. Near the end of the interview the participants were given an opportunity to make additional comments and add any relevant information that were not covered by the interview questions.

3.3.3 Specific Aim Analysis

Aim 3. Qualitatively explore the factors that influence clinicians' intention to use IHTs.

The recordings were transcribed at local transcription company (tMedica, 2017), which provides services for transcription of interview data for qualitative research. Once transcribed, the accuracy of the transcription was checked by reading the transcript while listening to the recording and inserting any relevant field notes or observations made during the interview. Any identifiable references to the participant or other individuals were removed and each transcript was labeled with an ID number indicating the participant's profession (e.g., physician 1, physician 2, nurse practitioner 1, nurse practitioner 2, etc.). Next, the transcribed data were transferred from MS Word to ATLAS.ti (atlasti.com, 2017). The use of ATLAS.ti software assisted in exploration and organization of the data and assigning codes and categories to the text (Hwang, 2007). The student assistant and the primary investigator separately read and assigned initial codes to the transcribed text, and consensus was reached by discussion in case of disagreement. An expert in qualitative research (PhD prepared) reviewed the first few coded transcripts and the initial codebook before proceeding with further coding. Codes were analyzed using thematic analysis (Guest, MacQueen, & Namey, 2012) and organized into categories to reflect potential influencing factors. Concepts from the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), as well as other theories, were used to organize and frame the findings.

3.3.4 Trustworthiness and Rigor

The following criteria were used to establish the trustworthiness of qualitative methods (Lincoln & Guba, 1985). *Credibility* (truth-value), which is similar to internal validity in quantitative

research, was achieved by evaluating the "representativeness of the data as a whole" (Thomas & Magilvy, 2011). After data analysis, selected participants were contacted, known as member checking (Birt, Scott, Cavers, Campbell, & Walter, 2016), to review the findings and solicit their opinions and suggestions about how accurately their perspectives were presented (Beck, 1993). *Transferability* (applicability) was accomplished by providing a "thick description" of the perspectives that were expressed and the context that is described during interviews about the participants' perspectives, beliefs, and work environment. *Dependability*, defined as the consistency of findings over time, and *confirmability*, the objectivity of the data (Beck, 1993; Lincoln & Guba, 1985), were promoted by asking a second coder, who is experienced in qualitative research, to review the analytic process starting with excerpts of transcribed, un-coded text and culminating in the derived final categories (audit trail) (Tuckett, 2005).

3.4 MIXED-METHODS SYNTHESIS PLAN

Aim 4. Integrate the findings from the quantitative and qualitative inquiries to provide a multi-dimensional, rich description of factors that influence clinicians' intention to use IHTs.

Integration of findings from both phases was presented through "joint displays" method in which visual means are used to display a bigger picture that is not gained by either quantitative or qualitative approaches separately (Fetters et al., 2013). Therefore, to extend the findings from the quantitative phase, importance-performance matrix analysis (IPMA) was performed (Hock, Ringle, & Sarstedt, 2010). This additional analysis was used to create separate importance-performance maps based on the findings that emerge from the qualitative phase. The IPMA analysis was conducted using the SmartPLS 3.2.7 software (Ringle et al., 2015).

3.5 POTENTIAL LIMITATIONS AND ALTERNATIVE APPROACHES

One of the major limitations in this study is the small sample size considering the number of predictors included in our model. While the minimum sample size (n=40) was calculated based on the rule of thumb by Hair et al. (2011), it might not be powerful enough to test the coefficients of each predictor individually. Therefore, the individual coefficients in the final model were interpreted with caution.

A potential method to overcome this limitation would be to increase the sample size. Since funding was available to recruit more participants, this option was considered because the recruitment process proceeded swiftly and efficiently with a high consent rate. This was accomplished within the study timeline by extending the duration of phase I to run concurrently with phase II. In other words, a few participants who completed the survey were selected to participate in the interviews while the survey phase continued to recruit new participants.

Another possible limitation was that the sample was drawn from one center. This might impact the generalizability of the results knowing that many of the factors in our model, such as organizational context factors, are directly impacted by the organizational setting. Therefore, the participants in this sample were recruited from a variety of clinical departments and hospitals within a large healthcare system to represent discrepancies in work environments and workflow styles. In addition, since data were not collected from participants who did not consent in the study, the conclusion about the representativeness of the achieved sample was unknown. However, medical directors were approached to provide basic descriptive statistics of clinicians that met our inclusion criteria in their departments, and these statistics were qualitatively compared with our achieved sample.

3.6 DESCRIPTION OF HUMAN SUBJECTS

3.6.1 Participant Population and Sources of Research Material

This study targeted clinicians (physicians, physician assistants, nurse practitioners, and nurses) at one center, the University of Pittsburgh Medical Center (UPMC). All clinicians who are involved in care of patients with end-stage heart and/or lung failure or transplant are eligible. The research material obtained from clinicians during the study included clinician factors collected via completion of measures using online survey, and qualitative data collected via face-to-face interviews that were recorded and transcribed into digital text.

3.6.2 Recruitment and Consent Procedures

The study participants were approached via e-mail for participation. After institutional review board approval, medical directors of relevant departments were asked to send an email to clinicians introducing them to the study with a link to the webpage of the online survey. The webpage included an introduction about the study, its purpose, expectations from participants, and any anticipated benefits or risks. Clinicians who choose to participate were provided informed consent at the beginning of the survey, which was assumed if they proceed. In addition, the informed consent stated that the participant might be contacted in the future for a face-to-face interview. Clinicians who are selected for interview and agreed to participate were asked to confirm consent at the time of the interview. Participants were apprised that the collected data would remain confidential and would be used for the study purposes only. Participants had the right to decide whether to participate, refuse, or withdraw anytime from the study. Participants were offered a

stipend of $30 for completing the survey and $30 per interview, which is considered reasonable to off-set their time for participation.

3.6.3 Potential Risks and Risk Management Procedures

To assure the protection of clinicians as human subjects, the protocol of the study was approved by the University of Pittsburgh's Institutional Review Board for approval prior to any enrollment (Appendix C). This study offers no immediate benefits to participants, and any risks associated with this proposed study are believed to be minimal and include threats to participants' data safety and security. Data from the online survey were linked to participant's electronic e-mail addresses, which are considered identifiers, to purposefully sample for the interviews. However, confidentiality of the data was maintained by 1) using the Qualtrics® survey software that was approved by the University of Pittsburgh's Institutional Review Board and meets University Data Security standards; and 2) removing identifiers from the extracted data before data sharing and/or conducting analysis so that the identities of participants were indicated in the surveys by case numbers only. The recorded interviews were transcribed and any names or information that could identify participants were removed from the transcripts. Then, they were connected to the aforementioned case numbers and stored in locked cabinet in the School of Nursing. Only the study investigators have access to the data. The research records will be kept for no less than five years, then destroyed.

3.6.4 Gender and Minority Inclusion

This study will sample from a finite population that includes clinicians of both genders and different racial/ethnic backgrounds. No potential participant was excluded from the study based on gender, race, or ethnicity. All potential participants had an equal opportunity to participate in the study, and they all received the same e-mail message for initial recruitment. Representation of gender and minority was considered in the purposive sampling of participants for the interviews.

4.0 MANUSCRIPT 2: "FACTORS AFFECTING CLINICIANS' ACCEPTANCE OF INTERACTIVE HEALTH TECHNOLOGIES TO SUPPORT PATIENT SELF-MANAGEMENT"

4.1 ABSTRACT

Background: Optimal management of patients with chronic cardiopulmonary illness requires a longitudinal care perspective with an emphasis on self-management. The collaboration between patients and their clinicians through interactive health technologies (IHTs) supports self-management behaviors and thus helps in the prevention and early treatment of complications. However, little is known about the factors that influence clinicians' intention to use IHTs, an issue that is vital to the success of such technologies.

Methods: A cross-sectional correlational study was conducted where clinicians (physicians, physician assistants, nurse practitioners, care coordinators) were surveyed for their perceptions about the adoption of IHTs. After viewing an IHT example, the survey was comprised of items that corresponded to concepts of a modified version of the Technology Acceptance Model 3. Partial least squares structural equation modeling was used to assess the associations between the model variables.

Results: Of the 82 clinicians included, 70% were female, 17% physicians, 40% transplant clinicians, age range 25-65 years. Perceived usefulness ($b= 0.52$, $p <.001$; $R^2=.64$) directly predicted intention to use IHTs. Subjective norms (views of other colleagues, $b= 0.25$, $p <.001$) and compatibility with work style ($b= 0.66$, $p <.001$) significantly predicted perceived usefulness. In turn, perceived ease of use ($b= 0.54$, $p <.001$) and facilitating conditions (e.g., organizational

support, b= 0.27, p <.001) significantly predicted compatibility. On the other hand, clinicians' beliefs about patient self-management (b= 0.46, p <.001) significantly predicted subjective norms. Males and physicians were more concerned about the compatibility of the IHTs with their workflow while females were influenced by the subjective norms in their workplace. Clinicians expected the mandatory use of IHTs to be accompanied by adequate organizational support, and voluntary use to be accompanied by easy to use IHTs.

Conclusions: A better understanding of the factors driving clinicians' decisions to adopt IHTs will inform their future development, acceptance, and adoption to support patient self-management and ultimately improve health outcomes.

4.2 INTRODUCTION

Chronic diseases, such as end-stage lung diseases, are the leading cause of mortality, morbidity and health resource utilization in the U.S. (Centers for Disease Control and Prevention, 2015; Stearns et al., 2000). Self-management is an interactive process in which individuals (patients and clinicians) collaborate to prevent and provide early detection of problems that arise with chronic illness and improve health outcomes (Lorig & Holman, 2003; Schulman-Green et al., 2012). The use of mobile health (mHealth) technologies provides real-time monitoring, detection of changes in health status, and the ability to deliver interventions, including the encouragement of patient's self-management (Kumar et al., 2013; Lanseng & Andreassen, 2007). Specifically, interactive health technologies (IHTs) are designed to encourage patients' self-management through the use of mHealth technologies that provide flexible and real-time monitoring, detection of changes in health status, and the ability to deliver interventions (Kumar et al., 2013; Lanseng &

Andreassen, 2007; Shahriyar et al., 2009). Furthermore, IHTs facilitate patient-clinician communication by connecting patient terminals (mobile applications) to clinician web-based portals for personalized feedback (De Vito Dabbs et al., 2009; Kollmann et al., 2007).

However, the implementation and acceptance of health technology, specifically IHTs face many barriers (Bishop, Press, Mendelsohn, & Casalino, 2013; Boonstra & Broekhuis, 2010; Schulte et al., 2016). The unexpected consequences of technology use on end-users' reactions, including both patients and clinicians, play a major role in the relatively slow development of health information technology (IT) (Holden & Karsh, 2010). The majority of the research studies in the literature focus on the patients' side and their acceptance of IHTs when self-caring for themselves, while there is a lack of studies from the perspective of the healthcare providers. Therefore, the aim of this study is to understand clinicians' acceptance of IHTs to support patients' self-management using a proposed conceptual model.

4.2.1 Conceptual Model

4.2.1.1 Theoretical Background

Several theoretical models about adoption and use of new technologies have been proposed. Among the first theories to be applied were the Theory of Reasoned Action (TRA) (Fisbein & Ajzen, 1975), the Technology Acceptance Model (TAM) (F.D. Davis, 1989; F. D. Davis et al., 1989), the Theory of Planned Behavior (TPB) that combines both TRA and TAM (Ajzen et al., 1991), and the Innovation Diffusion Theory (Rogers, 2010).

Because of its relative simplicity and ability to explain considerable variance (around 40%) in users' intention to use new technologies, the TAM compares favorably to other models (TRA and TBP) and thus has been extensively and empirically tested in the literature and found to be

parsimonious (P. Y. K. Chau & P. J.-H. Hu, 2002; Hong et al., 2006; Venkatesh & Davis, 2000). Indeed, the TAM is the most popular model among its counterparts and accounts for about 30-40% of the literature about information technology acceptance (Holden & Karsh, 2010). The TAM was based on the TR and purports that internal beliefs mediate the impact of external variables (e.g., task and user characteristics) on intention to use and the actual use of technology (F. D. Davis et al., 1989). More specifically, perceived ease of use and perceived usefulness are the main determinants of users' intentions and actual use of new technologies. The extensive utilization of the TAM resulted in a better understanding of its underlying concepts and the relationships between them and its strengths and weaknesses. Hence, the original model was refined and expanded with the major upgrades revisions being the Technology Acceptance Model 2 (TAM2), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), and finally TAM3 (Venkatesh & Bala, 2008).

The TAM3 was introduced in 2008 after two decades of ongoing testing and implementation in the field. The main updates included determinants of perceived ease of use by utilizing the anchoring and adjustment notion of human decision making (Venkatesh & Bala, 2008). The authors argued that the inclusion of such variables aid managers to develop more informed decisions about the intervention strategies that lead to an efficient utilization of the new technology.

4.2.1.2 Research Hypotheses

The approach of adding variables is the dominant method for enhancing and testing the TAM in healthcare (Holden & Karsh, 2010), and it is also a common and effective method for expanding and deepening current behavioral frameworks and theories (Conner & Armitage, 1998; Langdridge et al., 2007; Perugini & Bagozzi, 2001). Therefore, a modified version of the

Technology Acceptance Model 3 (TAM3) was introduced and enhanced by adding constructs from the similar groundwork on the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) and other instruments to fit the context of the IHTs' setting (research hypotheses, H1-H9).

While actual use is the precise way to measure the adoption of any given system, sometimes the direct measure of use is not possible or realistic. According to the TAM, when users are presented with a new technology, their acceptance to use this technology is expressed in their behavioral intention to use it (BIU) (F.D. Davis, 1989; Mathieson, 1991). Similar to the TAM, BIU was considered the outcome variable in our model to represent clinicians' acceptance of IHTs.

Perceived usefulness (PU) is "the degree to which an individual believes that using a particular system would enhance his or her job performance" (F D Davis, 1986). This follows the notion that any system will be viewed as useful when it demonstrates a positive use-benefit relationship (F.D. Davis, 1989). The concept has been consistently reported as the significant determinant of IU in technology acceptance research (Or & Karsh, 2009; Venkatesh & Davis, 2000) even in the context of IHTs (M. P. Gagnon, Orruno, et al., 2012; Orruno et al., 2011). Previous research articles reported *relative advantage*, a similar construct used in the UTAUT to describe the degree to which the use of IHTs is perceived as superior to the precursor practices (Venkatesh et al., 2003), as one of the factors for adopting IHTs (de Vries et al., 2017; Kuhn et al., 2014; Okazaki et al., 2012; Schulte et al., 2016; Timmerman et al., 2016; Verwey et al., 2014). Although the UTAUT made a distinction between relative advantage and perceived usefulness (Venkatesh et al., 2003), later research considered them as the same construct (M. P. Gagnon, Desmartis, et al., 2012; Wu et al., 2007) and the Technology Acceptance Model 3 (TAM3)

included questions from relative advantage to measure perceived usefulness. Therefore, in our model we only used PU and not relative advantage.

H1: There is a significant positive relationship between perceived usefulness (PU) and clinicians' behavioral intention to use IHTs.

The *compatibility* (COM) concept was derived from the Innovation Diffusion Theory (Rogers, 2010), and is defined as "the degree to which the innovation is perceived to be consistent with potential users' existing values, prior experiences and needs" (Wu et al., 2007). The concept was widely reported as an influencing factor in explaining the technology acceptance among clinicians (Chau & Hu, 2001; M. P. Gagnon, Orruno, et al., 2012). In the healthcare setting, COM describes clinicians' resistance to change their routine in response to stress created by using new technology (Jung & Loria, 2010; Venkatesh et al., 2000; Ye, 2008). We predict that clinicians will consider IHTs useful in their care if it was consistent with their needs and their clinical work routine.

H2: There is a significant positive relationship between compatibility (COM) and clinicians' behavioral intention to use IHTs.

H3: There is a significant positive relationship between compatibility and perceived usefulness (PU) of IHTs.

According to the work by Venkatesh et al. (2003) the UTAUT, *facilitating conditions* (FC) described as "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system." In that model, FC was considered as a predictor of actual usage rather than BIU because of the presence of effort expectancy (ease of system use and implementation) that captures organizational support infrastructure (Venkatesh et al., 2003) and previously found to fully mediate the relationship between SF and BIU (Venkatesh, 2000).

However, later research found that incorporated FC into TAM, instead of UTAUT, found FC as a significant predictor of BIU. Furthermore, some studies reported FC as the primary determinant of BIU among hospital personnel in general (Aggelidis & Chatzoglou, 2009), and consistently among healthcare professional in telemedicine in particular (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012; Orruno et al., 2011). In addition, we predict the presence of the necessary organizational support for clinicians will impact their views about the compatibility of IHTs.

H4: There is a significant positive relationship between facilitating conditions (FC) and clinicians' behavioral intention to use IHTs.

H5: There is a significant positive relationship between facilitating conditions (FC) and compatibility of IHTs.

Perceived ease of use (PEOU) is defined as "the degree to which a person believes that using a particular system would be free from effort" (F.D. Davis, 1989, p. 320). A large body of literature has accumulated in support of viewing PEOU, along with PU, as one of the most reliable predictors of technology acceptance (Or & Karsh, 2009; Venkatesh, 2000). That is, users tend to prefer to use less complicated technologies than those that are hard to use. However, clinicians did not consider PEOU as a key determinant in their intention to use IHTs (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012). Instead, clinicians were worried about deviating from their work routine by spending too much time explaining the IHTs to their patients than the clinical counseling itself (Verwey et al., 2014).

H6: There is a significant positive relationship between perceived ease of use (PEOU) and compatibility of IHTs.

Subjective norms (SN) is a key underpinning in the TPB and is defined as the "person's perception that most people who are important to him think he should or should not perform the

behavior in question" (Fisbein & Ajzen, 1975, p. 302). When examined at the presence of other factors, SN had no significant impact on intention to use IHTs (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012). Venkatesh and Davis (2000) argued that even when individuals do not intend to perform a behavior, they may do it merely because they think it is an expectation from a person whom they have the motivation to comply with, and thus it was embraced in TAM2 and TAM3 to span the social influence process on perceived usefulness (Venkatesh & Bala, 2008). Hence, we theorize that clinicians have a higher tendency to view IHTs as useful when the people important to them in the organization do so.

H7: There is a significant positive relationship between subjective norms (SN) and perceived usefulness (PU) of IHTs.

The role of the clinician is pivotal in activating patients to further engage in their own care and achieve their desired health goals. In fact, it was empirically found that positive clinicians' beliefs about patient self-management are directly associated with patient activation (Alvarez et al., 2016) and perceived quality of care (Ratanawongsa et al., 2012). However, many clinicians have not received training about strategies to promote patient engagement and do not view patient support as part of their role as clinicians (Alvarez et al., 2016) and thus the level of support of patient self-management varies among clinicians (J. H. Hibbard et al., 2010; NHS England, 2015). One of the major shortfalls of research on clinicians' acceptance of IHTs is the erroneous assumption that all clinicians are prepared and committed to supporting patient self-management. Therefore, we theorize that the discrepancy in clinicians' beliefs about patient self-management (CBSM) directly impact their intention to use IHTs and subjective norms.

H8: There is a significant positive relationship between clinicians' beliefs about patient self-management (CBSM) and their behavioral intention to use IHTs.

H9: There is a significant positive relationship between clinicians' beliefs about patient self-management (CBSM) and subjective norms (SN).

In their study that describes physicians' acceptance of telemedicine, P. Y. K. Chau and P. J.-H. Hu (2002) laid the groundwork for a framework that is an adaptation of TAM and a better fit for this population. The authors categorized the determinants of intention to use into individual (professional), technological, and implementation (organizational) contexts. Following the same approach, the independent (reflective) variables in the proposed model were categorized into professional (individual), technological, and organizational (implementation) contexts to meet the needs of our niche population, i.e. clinicians using IHTs to support self-management for patients with cardiopulmonary disorders (Figure 8).

Socio-demographic characteristics, age and gender, were included in the UTAUT as moderators to all relationships in the model (Venkatesh et al., 2003). In the context of IHTs, younger age (<40 years) was previously found to be related to more favorable perceptions about IHTs (Kuhn et al., 2014; Okazaki et al., 2012). However, other studies have reported both gender and age to have no significant impact on intention to use (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012).

Professional affiliation was previously found to impact clinicians' level of support of patient self-management. For example, nurses were more supportive of self-management than physicians and other allied healthcare professionals (NHS England, 2015). Physicians additionally showed negative attitudes toward the use of the online communication with patients due to concerns about the time and money (Timmerman et al., 2016).

Despite the assumption that system usage is a must in mandatory setting, some users still choose not to comply (Venkatesh & Davis, 2000). As a result, both TAM2 and TAM3 used the perceived rather than actual voluntariness as a contextual variable (Venkatesh & Bala, 2008). Therefore, and in addition to the primary hypotheses testing, we explored the possible moderation effect of age, gender, profession and voluntariness on the proposed research model.

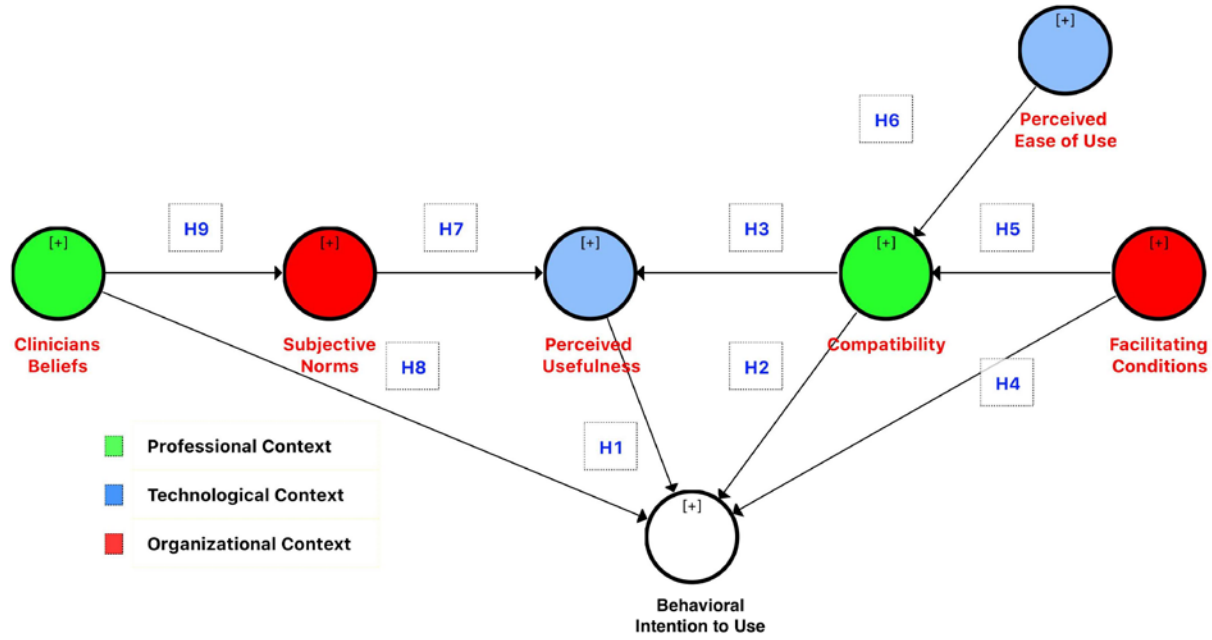

Figure 8. Proposed research model and hypotheses

4.3 METHODS

4.3.1 Setting and Sample

The study was conducted and in a large health network system (University of Pittsburgh Medical Center) and the participants were recruited from the cardiothoracic transplant program, the outpatient comprehensive lung center, the outpatient cardiac clinic, and the cardiac rehabilitation

unit. Clinicians who were eligible to participate included physicians, physician assistants, nurse practitioners, and care coordinators (nurses and physiotherapists) who care for patients with chronic cardiopulmonary disorders. Participants were offered a stipend of $30 for completing the survey to enhance the response rate. This study was approved by the institutional review board at the University of Pittsburgh.

4.3.2 Measures and Data Collection

Using a secure online survey system, the clinical director of each department sent individual invitation emails to all clinicians in their department who met the eligibility criteria for the study. The survey included a description of the study, its purpose, expectations from participants, and any anticipated benefits or risks. Clinicians who chose to participate provided informed consent at the beginning of the survey, which is assumed if they proceed.

Socio-demographics were collected at the beginning of the survey. Then, the CBSM variable was measured using the Clinician Support for Patient Activation Measure (CS-PAM) (J. H. Hibbard et al., 2010). The scale uses the modified 13-items of a 4-point Likert-type that ranges from “not at all important” to “very important”. The CS-PAM was found to have acceptable internal consistency reliability (Cronbach’s $\alpha = 0.82\text{-}0.97$) and able to differentiate clinicians from different countries based on their level of beliefs and attitudes towards patient activation and self-management (J. H. Hibbard et al., 2010; NHS England, 2015; Rademakers et al., 2015; Stoilkova-Hartmann et al., 2015). The CS-PAM was licensed and scaled for this study by the developer, Insignia Health, University of Oregon, United States (Insignia Health, 2010). The CS-PAM was evaluated in the first half of the survey to measure the bare CBSM to avoid contaminating their perspectives with the next step in which an example of IHT (Pocket PATH® Synergy) was

introduced using simulation (illustrative voice over-video and screenshots). The approach of providing a description of the sample IHT before surveying clinicians' intention to use is not uncommon in the literature (Kuhn et al., 2014; Okazaki et al., 2012). Finally, a list of 7-point Likert-type questions was used to measure the rest of the variables in the research model. These questions were adapted from the TAM3 and the UTAUT and were previously reported to be valid and reliable (Venkatesh & Bala, 2008; Venkatesh et al., 2003). For instance, the outcome variable was measured by three questions and thus the possible final sum-score ranged from 3-21 (Appendix A).

4.3.3 Statistical Analysis

The research model was assessed using partial least squares - structural equation modeling PLS-SEM) as applied in SmartPLS 3.2.7 (Ringle et al., 2015). The PLS-SEM method is preferred over the traditional covariance-based SEM because 1) the aim of this study is to explore and extend an existing theory, and 2) the small sample size (Hair et al., 2011; Jörskog & Wold, 1982).

The reflective (latent) constructs were evaluated for reliability using the internal consistency reliability (Cronbach's alpha), rho_A, and composite reliability measures. For a construct to be reliable, each of these measures should be >.7 (Hair Jr et al., 2017; Nunnally, 1978). In addition, factor outer loadings and the average variance extracted (AVE) were used to assess the convergent validity of the constructs. The outer loading for each of the of the constructs should be at least 0.7 to be considered as good, while the AVE should exceed 0.5 to be acceptable (Hair Jr et al., 2017). The discriminant validity was assessed using factor loadings, Fornell-Larcker Criterion (Fornell & Larcker, 1981), and the Heterotrait-Monotrait Ratio (HTMT) (Henseler et al., 2014). Fornell and Larcker (1981) showed that the variance shared between items within the same

construct should exceed the variance shared with any other construct. However, for the HTMT, the values below 0.90 express discriminant validity between the two constructs (Henseler et al., 2014).

Stone-Geisser Q^2 (cross-validated redundancy) was used to evaluate the predictive relevance of the model using the blindfolding procedure. (Hair Jr et al., 2017; Stone, 1974). A Q^2 larger than zero for any dependent construct indicates that the model has a predictive relevance for that construct (Hair Jr et al., 2017). The PLS-SEM analysis was conducted after that using the bootstrap procedure with 10,000 resamples to evaluate the model's inference statistics. The moderation effect of age (<45 years vs. $\geq$ 45 years, gender (male vs. female), profession (physician vs. non-physician) and voluntariness (voluntary vs. involuntary). The voluntariness construct was dichotomized based on the median (13) of the sum score to differentiate the subjects based on their expectations of how voluntary the implementation of IHTs will be at their workplace.

4.4 RESULTS

4.4.1 Sample Characteristics

During the period between May and September 2017, 86 out of 124 invited clinicians started to the online survey. However, one response did not provide any information beyond socio-demographics and the three did not complete any of the questions about the use of IHTs. Therefore, the final total sample used in the analysis was 82, which represents 66.1% response rate. Of those, only 4 (4.9%) completed the survey on their smartphone web browsers and the rest used personal computers.

The characteristics of the sample are presented in Table 2. More than one-third of the participants were between the 35-44 years old (35.4%), and the majority (59.5%) were female. More than half the sample (57.3%) had at least master's degree, and only 17.1% were physicians or surgeons. Most of the participants reported positive intention to use IHTs in their practice (mean= 16.30 $\pm$ 3.18).

Table 2. Sample Characteristics

Characteristic	**Total (N=82)**
Age	
18 - 24	1 (1.2%)
25 - 34	13 (15.9%)
35 - 44	29 (35.4%)
45 - 54	16 (19.5%)
55 - 64	23 (28%)
Gender, female	57 (69.5%)
Education	
Associate degree	11 (13.4%)
Bachelor's degree	24 (29.3%)
Master's degree	30 (36.6%)
Doctorate/ terminal degree	17 (20.7%)
Profession	
Physician	14 (17.1%)
Physician assistant	6 (7.3%)
Nurse practitioner	5 (6.1%)
Transplant / care coordinator	28 (34.1%)
Registered nurse	29 (35.4%)
Specialty (if physician)	
Surgeon	1 (7.1%)
Pulmonologist	7 (50.0%)
Cardiologist	4 (28.6%)
Other	2 (14.3%)

4.4.2 Measurement Properties

The results from the measurement model are presented in Table 3. The values of Cronbach's alpha, rho_A, and composite reliability for all constructs were above the recommended value of 0.7 and

thus indicated good reliability of the measures. In addition, all the values for factor loadings exceeded the minimum requirement of 0.7, and AVE values were far above the threshold value of 0.5. Therefore, all the measures showed acceptable convergent validity.

Table 3. Measurement Model

Construct	Item	Factor Outer Loading	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
BIU	BIU1	0.902	0.87	0.88	0.92	0.79
	BIU2	0.949				
	BIU3	0.812				
COM	COM1	0.796	0.87	0.89	0.92	0.79
	COM2	0.938				
	COM3	0.933				
FC	FC1	0.811	0.79	0.81	0.87	0.70
	FC2	0.835				
	FC3	0.859				
PEOU	PEOU1	0.842	0.91	0.91	0.94	0.79
	PEOU2	0.835				
	PEOU3	0.928				
	PEOU4	0.940				
PU	PU1	0.913	0.93	0.94	0.95	0.84
	PU2	0.902				
	PU3	0.938				
	PU4	0.904				
SN	SN1	0.903	0.90	0.90	0.93	0.76
	SN2	0.898				
	SN3	0.875				
	SN4	0.819				
VOL	VOL1	0.924	0.87	0.93	0.92	0.79
	VOL2	0.924				
	VOL3	0.820				

The values for HTMT were below the recommended cut-off value of 0.9 except for the shared value between compatibility and perceived usefulness (Table 4). However, all the constructs in the model met the Fornell-Larcker criteria since the square root of the variance for

each construct was larger than the relationships between it and any other construct (Table 4). Hence, the measures in the model showed an acceptable level of discriminant validity.

Table 4. Discriminant Validity – Latent Variables

Heterotrait-Monotrait Ratio (HTMT)

	BIU	COM	FC	PEOU	PU	SN	VOL
BIU							
COM	0.84						
FC	0.70	0.75					
PEOU	0.68	0.81	0.76				
PU	0.86	0.94	0.71	0.78			
SN	0.73	0.83	0.71	0.75	0.81		
VOL	0.24	0.30	0.32	0.57	0.28	0.29	

Fornell-Larcker Criterion

BIU	0.89						
COM	0.74	0.89					
FC	0.58	0.63	0.84				
PEOU	0.61	0.73	0.67	0.89			
PU	0.78	0.85	0.62	0.72	0.91		
SN	0.64	0.74	0.60	0.69	0.74	0.87	
VOL	0.22	0.27	0.28	0.50	0.27	0.27	0.89

4.4.3 Model Validation

The Stone-Geisser Q^2 ranged from 0.15 - 0.58 for the endogenous variables in the model using the blindfolding technique. Therefore, the model showed a predictive relevance in explaining the dependent constructs in our model. Results from the PLS-SEM analysis and the hypotheses testing are shown in Table 5. Of the nine hypotheses, six were found to be extremely significant while three were not supported (H2, H4, and H8).

Table 5. Hypothesis Testing

Hypothesis	Path	Beta Coefficient	T Statistics	P Value	Hypothesis Testing
H1	PU → BIU	0.52	3.97	**<.001**	Supported
H2	COM → BIU	0.23	1.65	0.10	Not supported
H3	COM → PU	0.66	8.84	**<.001**	Supported
H4	FC → BIU	0.12	1.42	0.15	Not supported
H5	FC → COM	0.27	3.02	**<.001**	Supported
H6	PEOU → COM	0.54	6.36	**<.001**	Supported
H7	SN → PU	0.25	2.98	**<.001**	Supported
H8	CBSM → BIU	-0.03	0.37	0.71	Not supported
H9	CBSM → SN	0.46	5.72	**<.001**	Supported

As depicted in Figure 9, the model explained 64.1% of the variance in BIU. Only PU had a significant direct impact on BIU (b= 0.52, p <.001), while compatibility, FC, and CBSM were not significant predictors of BIU. PU was significantly predicted by SN (b= 0.25, p <.001) and compatibility (b= 0.66, p <.001). In turn, this latter construct, was predicted by PEOU (b= 0.54, p <.001) and FC (b= 0.27, p <.001). On the other hand, SN was significantly predicted by CBSM (b= 0.46, p <.001).

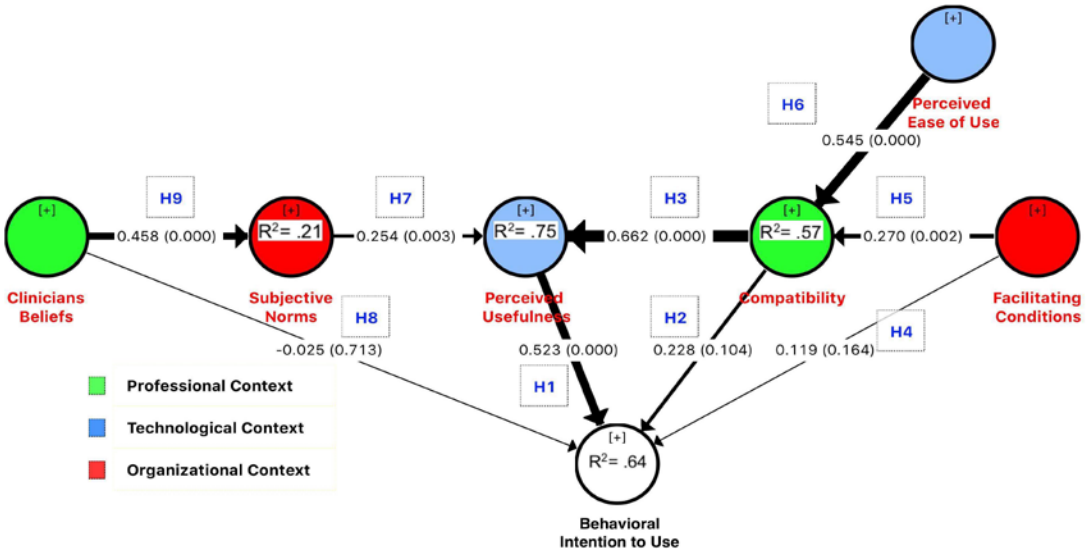

Figure 9. Partial least squares (PLS) analysis results of the research conceptual model.

The numbers reported on the paths represent the path coefficients with p-values listed in parentheses; values are rounded to the third decimal. The thickness of the path arrows represents the strength of the relationships (path coefficients).

4.4.4 Moderation

The moderating effect of age and gender on each of the relationships in the conceptual research model are displayed in Table 6. Age was not a moderator for any of the relationships in the model. However, compared to females, males had a higher impact of compatibility on PU (0.98 vs. 0.59, p=0.02) but less impact of SN (-0.11 vs. 0.34, p=0.02). Furthermore, females viewed an IHT to be more compatible with their workflow if it was easier to use (0.22 vs. .66, p=.04).

Table 6. Age and Gender Moderation

Path	**Age**				**Gender**			
	>45 yrs	<45 yrs			Male	Female		
	Path Coefficients		|diff|	P-Value	Path Coefficients		|diff|	P-Value
CBSM → BIU	0.06	-0.06	0.12	0.45	-0.03	-0.03	0.00	0.99
CBSM → SN	0.37	0.47	0.10	0.60	0.40	0.39	0.01	0.96
COM → BIU	0.05	0.31	0.26	0.44	0.35	0.20	0.15	0.65
COM → PU	0.79	0.64	0.14	0.38	0.98	0.59	0.39	**0.02**
FC → BIU	0.17	0.07	0.10	0.64	0.18	0.09	0.09	0.67
FC → COM	0.53	0.23	0.29	0.18	0.45	0.22	0.23	0.31
PEOU → COM	0.21	0.62	0.41	0.07	0.22	0.66	0.44	**0.04**
PU → BIU	0.65	0.49	0.17	0.61	0.43	0.54	0.10	0.73
SN → PU	0.09	0.30	0.21	0.28	-0.11	0.34	0.46	**0.02**

The differences in the hypothesized relations by the type of profession and the voluntariness of the system are shown in Table 7. The impact of compatibility on perceived usefulness was higher among physicians compared to other clinicians (0.99 vs. 0.59, p=0.02). Compatibility was more determined by FC for clinicians who identified the use of IHTs to be mandatory at their workplace (-0.13 vs. 0.51, p<0.001), but for those who expected it to be voluntary, compatibility was more determined by PEOU (0.90 vs. 0.42, p<0.001).

Table 7. Profession and Voluntariness Moderation

Path	Profession – Physician				Voluntariness			
	Yes	No			Yes	No		
	Path Coefficients		|diff|	P-Value	Path Coefficients		|diff|	P-Value
CBSM → BIU	-0.23	-0.05	0.19	0.75	-0.01	-0.04	0.03	0.85
CBSM → SN	0.35	0.41	0.06	0.57	0.53	0.36	0.17	0.32
COM → BIU	0.49	0.12	0.37	0.16	0.06	0.29	0.23	0.47
COM → PU	0.99	0.59	0.40	**0.02**	0.68	0.63	0.05	0.74
FC → BIU	-0.09	0.22	0.31	0.84	0.04	0.12	0.08	0.72
FC → COM	0.33	0.28	0.05	0.42	-0.13	0.51	0.63	**<0.001**
PEOU → COM	0.33	0.58	0.25	0.85	0.90	0.42	0.47	**<0.001**
PU → BIU	0.52	0.52	0.00	0.47	0.77	0.44	0.32	0.26
SN → PU	-0.12	0.32	0.44	0.95	0.28	0.23	0.05	0.76

4.5 DISCUSSION

To our knowledge, this is among a few studies to evaluate clinicians' acceptance of IHTs in the United States. However, our study was unique in that clinician participants were exposed to a simulation (video with subtitles or detailed description of statistic screenshots) that guided them through an objective description of the features and functions of an IHT example. Most clinicians reported positive intention to use IHTs in their practice when caring for patients with chronic cardiopulmonary disorders. While this is crucial to the implementation success of IHTs from a managerial perspective, it is also important for patients' engagement and adoption. Patients are more likely to adopt IHTs that are endorsed by their doctors (de Vries et al., 2017) especially when they get feedback about their results (Timmerman et al., 2016).

Similar to previous studies, our hypothesized research model was able to explain a large degree of the variance in intention to use (Asua et al., 2012; M. P. Gagnon, Orruno, et al., 2012;

Kuhn et al., 2014; Okazaki et al., 2012). However, the results from this study show that PU is the only determinant of intention to use. This indicates that clinicians will only adopt an IHT if it is beneficial in improving the performance and efficiency of their work. This can be achieved by making the IHT compatible with their work (compatibility), especially for male physicians. Physicians, more than other clinicians, previously reported concerns that the time consumed in the two-way contact with their patients will outweigh the added value of the IHT (de Vries et al., 2017; Timmerman et al., 2016).

The present study makes a differentiation between the setting in which IHTs are deployed with regard to compatibility. For organizations where clinicians' adoption of IHTs is voluntary, the ease of use of the system (e.g., navigating the web portal and finding the required patient information) is a major factor to consider it as compatible with the work. However, when the use of IHTs is mandatory, clinicians expected the availability of adequate resources including training and technical IT support. For instance, clinicians considered the availability of helpdesk as one of the leading support features for an adoptable IHT (Timmerman et al., 2016). Therefore, healthcare organizations should have in mind that the implementation of new IHTs needs to be accompanied with adequate infrastructural support.

In this study, females and non-physician clinicians were more likely to view IHTs as useful when their peers did so. Okazaki et al. (2012) reported that many clinicians who are not tech-savvy might rely on the opinions of their colleagues' suggestions. Using early adopters of IHTs as role models for their colleagues would be important to make clinicians buy into the usefulness of IHTs. To our knowledge, this is the first study that includes clinicians' beliefs about patient self-management in studying intention to use and reports its impact on subjective norms. Our study found no significant direct impact of clinicians' beliefs about patient self-management on intention

to use, however, the indirect effect of this relationship was significant indicating a full mediation effect via subjective norms and perceived usefulness (the indirect effects are not reported in this paper in the interest of brevity). Clinicians who believed in giving more independence and responsibility to patients in making decisions about their own health were more likely to care about their colleagues' perspectives of IHTs. This might be related to the general assumption that clinicians who activate and listen more to their patients are more likely to listen to their peers' perceptions.

This study has two main limitations. First, the relatively small sample size to study a complex conceptual model. However, sample size wise, using the PLS-SEM methods is appropriate in this study. Hair et al. (2011) reported that the minimum sample size should be at least ten times the largest number of indicators to measure one construct and at least ten times the largest number of predictors for one latent variable. Following such criteria, the sample size in the present study is double the minimum requirement. Second, the study was conducted in one center, which limits the generalizability of the results. However, the participants in this sample came from a variety of clinical departments and hospitals within a large healthcare system. Clinicians in these departments have different work environments and workflow styles. Therefore, the results are likely generalizable to the role of clinicians in other settings with different care management styles and work cultures.

5.0 MANUSCRIPT 3: "CLINICIANS' PERCEPTIONS ABOUT INTERACTIVE HEALTH TECHNOLOGIES: A MIXED-METHODS STUDY"

5.1 ABSTRACT

Background: Interactive health technologies (IHTs) were developed to enhance patient self-management and health outcomes by providing a two-way communication between patients and their clinicians. However, despite its importance, little is known about clinicians' adoption of IHTs. This study aimed to provide a rich description of the factors impacting clinicians' intention to use IHTs.

Methods: A mixed-methods study. First, an online survey, comprised of items examining several factors thought to impact intention to use IHTs, was administered to clinicians (physicians, physician assistants, nurse practitioners, nurse care coordinators, and physiotherapist). Next, based on their characteristics and survey scores, a subgroup of clinicians was purposefully selected for participation in qualitative interviews that were analyzed using thematic analysis. The findings from both approaches were then combined to conduct importance-performance matrix analyses of the factors.

Results: The full sample included 82 clinicians who completed the survey of which 70% were female, 17% were physicians, 40% were transplant clinicians, with ages ranging from 25-65 years. Perceived usefulness was the only factor that directly predicted intention to use IHTs (B= 0.52, p <.001; R^2=.64). Six participants were identified and interviewed. Analysis of the interviews revealed perceived usefulness and compatibility with workflow were the most important factors influencing behavioral intention to use. Three distinct groups of clinicians emerged based on the

views they had in common and were most important to them. Nurses and care coordinators were more concerned about details in IHTs and required the availability of adequate organizational resources. Physicians were more interested in the overall picture and concerned about the compatibility of IHTs with their workflow. Nurse practitioners and physician assistants were willing to follow up with patients on a daily basis only in the outpatient setting.

Conclusions: The usefulness and compatibility of IHTs with clinicians' workflow are among the top priorities for successful deployment. In addition, the interface design of future IHTs should be tailored for different types of clinicians. The findings from this study have implications for policy makers and decision makers at healthcare organizations to make informed decisions about the deployment of IHTs, and developers and researchers to promote IHTs' innovation. As a result, clinicians may be more likely to integrate such enhanced systems into their work processes to better support patient self-management and ultimately improve health outcomes.

5.2 INTRODUCTION

Mobile technologies, including smartphones, are becoming increasingly ubiquitous, reaching a broad range of users worldwide. There average per 100 capita mobile cellular subscriptions was 101.5 worldwide and 127 in the United States in 2016 (The World Bank, 2017). This widespread use of mobile technologies has the potential to exert a significant influence on public health and healthcare delivery. It can influence when, where and how to deliver healthcare by opening the door for innovation and introduction of new applications in the healthcare field.

The use of mobile health (mHealth) technologies provides real-time monitoring, detection of changes in health status, and the ability to deliver interventions, including the encouragement of patient's self-management (Kumar et al., 2013; Lanseng & Andreassen, 2007). Of a special attention are the interactive health technologies (IHT) that facilitate patient-clinician communication by connecting patient terminals (mobile applications) to clinician web-based portals for personalized feedback are designed to encourage patient's self-management through the use of mobile health technologies. This connection provides flexible and real-time monitoring, detection of changes in health status, and the ability to deliver interventions (De Vito Dabbs et al., 2009; Kollmann et al., 2007).

However, the deployment of IHTs- as any other information technology in healthcare faces many barriers (Boonstra & Broekhuis, 2010), and many researchers consider information and communication technologies in healthcare to be somewhat lagging behind other industries (Hikmet & Chen, 2003; Wu et al., 2007; Zhang, Cocosila, & Archer, 2010). The unexpected consequences of technology use on end-users' reactions, including both patients and clinicians, play a major role in the relatively slow development of health IT (Holden & Karsh, 2010). Furthermore, newly applied technologies can lead to acceptance, use, and adoption of the system or to rejection,

misuse, and avoidance to utilize the new technology by end-users (Berg, 2001; Laerum, Ellingsen, & Faxvaag, 2001; Lapointe & Rivard, 2005; Markus, 1983). The majority of the research studies in the literature focus on the patients' side and their acceptance of IHTs when caring for themselves, while there is a lack of studies from the perspective of their clinicians.

The purpose of this mixed-methods study was to build upon on the findings of a previously conducted quantitative study that examined the strength and direction of the factors that influenced clinicians' intention to use IHTs. Although findings of the prior study revealed the perceived usefulness and compatibility of IHTs were among the top priorities for high adoption of IHTs, the quantitative approach alone is insufficient to describe technology adoption for new niche fields such as IHTs. More in-depth research designs, such as mixed methods, are helpful in approaching the complex phenomena of healthcare from different perspectives recognizing the contextual environmental influences for the intention to use IHTs. This was not possible to achieve using only the dominant quantitative approach, which is considered to be more "context-free" (Johnson & Onwuegbuzie, 2004; Walsh, 2015). Qualitative approaches are often better suited to explore the complex and dynamic nature of behaviors and experiences (Grypdonck, 1997) as they are more appropriate for developing and enhancing theoretical models than quantitative approaches (Sinuff et al., 2007). In this study, the qualitative findings assisted in providing further explanation (Sandelowski, 2000) of clinicians' responses to questions about the factors in the conceptual model. The use of a mixed-methods design to study clinicians' beliefs about IHTs provided a deeper understanding of the phenomenon that is of a highly complex social, technological, and cultural nature (Bossen et al., 2013; Scott & Briggs, 2009). That is, the findings from both approaches were integrated to generate a multi-dimensional, rich description of clinicians' intention to use IHTs.

5.3 METHODS

5.3.1 Mixed-Method Study Design

This mixed-methods study (Creswell et al., 2011) was comprised of three phases using explanatory sequential design (QUAN>qual) (Fetters et al., 2013; Sandelowski, 2000). First, a quantitative, a cross-sectional and correlational design was used to evaluate the influence of professional, technological, and organizational factors on clinicians' intention to use IHTs for patient self-management. Refer to section 4.3 for a detailed description of the methods for the quantitative phase including the sample, measures, data collection and data analysis.

Second, a qualitative descriptive design was used to further explain the factors that influence clinicians' beliefs about using IHTs to promote self-management. Third, both the quantitative and qualitative inquiries were integrated to provide a comprehensive picture about clinician's acceptance of IHTs.

5.3.2 Sample

Purposive criterion sampling was used to select a sample of participants for the qualitative study from clinicians who participated in the quantitative study. Criterion sampling, a kind of purposive sampling, used values for preconceived measures and scores to initiate the sampling strategy (Sandelowski, 2000). Participants' intense scores (upper and lower quartiles) were used for each of the professional, technological, and organizational factors, in addition to representatives from each of the professional affiliations (i.e. physician, physician assistant, nurse practitioner, and nurse) and both genders as criteria to achieve a sample that exemplifies variations in clinicians'

perspectives and characteristics. Participants were enrolled until saturation was reached where no further themes could be found (Sandelowski, 1995).

5.3.3 Data Collection

Interviews were conducted, using a semi-structured script as a guide including open-ended questions based on the purported factors to influence clinicians' intention to use IHTs to support patient self-management (Appendix B). One-on-one interviews were conducted by primary investigator (MOA) in a private room adjacent to the clinical setting based on the convenience of the participant. With the participant's permission, discussions were audiotaped and notes were taken during the interview. Participants were assured that the purpose was to gather their perceptions and there were no right or wrong responses. The interviews lasted about 25-50 minutes. Near the end of the interview, the participants were given the opportunity to make additional comments and add any relevant information that was not covered by the interview questions.

5.3.4 Data Analysis Plan

The recordings were transcribed verbatim and the accuracy of the transcription was double-checked. Any identifiable references to the participant or other individuals were removed, and each transcript was labeled with an ID number indicating the participant's role. Next, the transcribed data were transferred to ATLAS.ti, Mac version 1.6.0 (atlasti.com, 2017), to facilitate the exploration and organization of the data and the assignment of codes and themes to the text (Hwang, 2007). Two researchers separately read and assigned initial codes to the transcribed text,

and in case of disagreement, consensus was reached by discussion. Codes were then assigned themes (Guest et al., 2012) and organized into categories to reflect potential factors influencing clinicians' intention to use IHTs.

Integration of findings from both phases was presented through "joint displays" method in which visual means are used to display a bigger picture that is not gained by either quantitative or qualitative approaches separately (Fetters et al., 2013). Therefore, to extend the findings from the quantitative phase, importance-performance matrix analysis (IPMA) was performed (Hock et al., 2010). This additional analysis was used to create separate importance-performance maps based on the findings that emerge from the qualitative phase. The IPMA analysis was conducted using the SmartPLS 3.2.7 software (Ringle et al., 2015).

5.3.5 Trustworthiness and Rigor

The following criteria was used to establish the trustworthiness of qualitative methods (Lincoln & Guba, 1985). *Credibility* (truth-value), which is similar to internal validity in quantitative research, is achieved by evaluating the "representativeness of the data as a whole" (Thomas & Magilvy, 2011). After data analysis, selected participants were contacted to review the findings and provide their opinions and suggestions about the accuracy of presenting their perspectives about using IHTs (Beck, 1993). *Transferability* (applicability) was accomplished by providing a "thick description" of the perspectives that were expressed and the context that is described during interviews about the participants' perspectives, beliefs, and work environment. *Dependability*, defined as the consistency of findings over time and *confirmability*, the objectivity of the data (Beck, 1993; Lincoln & Guba, 1985) were promoted by asking a second coder, who is experienced

in qualitative research, to review the analytic process starting with excerpts of transcribed, un-coded text and culminating in the derived final categories (audit trail) (Tuckett, 2005).

5.4 RESULTS

5.4.1 Quantitative

Refer to section 4.4 for the quantitative results.

5.4.2 Qualitative

The sample characteristics are presented in Table 8. Of the six clinicians who participated in this study, five were female and the age ranged from 25-64 years. Clinicians were three care coordinators, one nurse practitioner, one physician assistant, and one physician. The sample included participants at each of the upper and lower quartiles of the scores of the professional, technological, and organizational contexts based on the quantitative results.

Several categories of factors that appeared to influence the intention to use IHTs emerged from the qualitative data analysis, which complemented the findings of the quantitative phase. Concepts from the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), as well as others, were used to organize and frame the findings.

Table 8. Qualitative Sample Characteristics

N =6	Context						Age Range	Gender	Profession
	Professional		Technological		Organizational				
	Low	*High*	*Low*	*High*	*Low*	*High*			
1		X		X			45-54	F	Care Coordinator
2			X		X		45-54	F	Nurse Practitioner
3			X				25-34	F	Physician Assistant
4				X		X	55-64	F	Care Coordinator
5			X				55-64	F	Care Coordinator
6	X		X				35-44	M	Physician

5.4.2.1 Belief about Patients' Self-Management

Clinicians expressed different perspectives about the degree to which they wanted to share power in making critical decisions with their patients. Clinicians' age was brought as one of the main factors that may influence clinicians' views about activating their patients. The old style for clinicians was to expect patients to adhere to the prescribed medical regimen without questioning the orders. However, recently, patients have the choice to challenge and "shop" for care that meets their own needs, but this is dependent on factors including the patient's education level and economic status.

"…but back then, the doctor had full reign and you know whatever the doctor said then the patients would just blindly accept and do, in general… Now with the changes in healthcare and as technology has improved the general population's understanding of health care, I do believe that the

patients are more self-advocates and more consumer-based where they will shop for care if they have the ability to do so... There is still a gap between patients that are self-advocates and consumers and patients that just blindly accept. I do think some of that is related to education and economic status in the world where they aren't as understanding or open to what is available to them or maybe it just simply isn't available to them." (Clinician 1, nurse/ transplant coordinator)

Some of the clinicians expressed their full support of patients making decisions and looking for information. However, some clinicians showed concerns when their patients looked for information, especially those with complicated medical regimens since complex patients have little room for creativity with regard to their medical regimen. The degree to which the patient can be activated also depends on the situation and the readiness of the patient.

"It [self-management] depends on the patient. Like one patient, I would like to see that they have a list of their weight every day when they come to clinic or I would like to see what your blood sugars were for the last two weeks. Whether you do it on your phone or on a computer program or on a piece of paper, I don't care and it depends on the patient… and if you read all of the side effects of the medicines, there are people who will say 'I'm not going to take prednisone because I read this and this and this and it's not good for me' and we said 'yes but you have to take prednisone'… they can only have so much creativity in their regimen because some of our medicines have to be taken 12 hours apart. We do encourage them to creatively take their medicines and spread them apart so that they don't feel nauseous… and if they are going

to go research things on Google then I want them to ask us before they make any changes to anything" (Clinician 2, nurse practitioner)

5.4.2.2 Profession Workflow Discrepancies

All the interviewed clinicians indicated that the adoption of IHTs should be determined by its impact on their daily work routine. Clinicians were stratified into three groups based on their work responsibilities and workflow: care coordinators (nurses and physiotherapists), advanced practitioners (nurse practitioners and physician assistants), and physicians. These groups span from lower to higher level of accountability for making decisions pertaining to patient care, respectively. Nurses and care coordinators are expected to follow up on each value communicated by their patients via IHTs, and to communicate doctor orders in a format that is easily comprehended by patients. However, physicians were concerned only about the abnormal values reported by their patients.

"… I know my colleagues who don't do it [reviewing patient values]. So, I think that you know again and some of that is their own choice and some of that is being too busy and some of that is you know a lot of the labs and values that drop into our inbox are essentially normal so I think that you know, the coordinators also review it too so a lot of my colleagues rely upon the coordinators to alert them where there are problems." (Clinician 6, physician, pulmonologist)

On the other hand, nurse practitioners and physician assistants were in the middle of the accountability spectrum between coordinators and physicians and play different roles based on the setting and their job expectations. Practitioners indicated that they will follow up more closely on

patient values if they were in an outpatient setting and there are no coordinators to perform that. However, in an inpatient setting or in the presence of care coordinators, they only are interested in viewing summaries of patient progress at home to aid in better diagnosis.

> *"In this setting [inpatient setting], the nurse practitioner and the physician's assistant in the hospital setting do not follow the person once they leave. Now, there are a few patients that the nurse practitioner in the clinic setting does follow as kind of a coordinator but that's a rare thing… we've got a whole system where we tell them to have labs on a certain day and the coordinator knows to look. Then, the coordinator says if there is anything wrong with the labs then she calls the right doctor and says what do you want me to do about this?" (Clinician 2, nurse practitioner)*

5.4.2.3 Performance Expectancy

The perceived benefit from the system (*perceived usefulness*) was consistently reported among clinicians as the main factor to make their decisions about intending to use IHTs. The perceived benefit can be either for the patient by improving their health outcomes or for the clinician by giving them the ability to follow-up on their patient health status.

> *"I believe to me and to my thought about other people, if they don't think it's useful and it's not providing any benefit not on their part or the patients' part then they wouldn't be willing to use it." (Clinician 5, nurse/ care coordinator)*

However, since the definition of usefulness is different across individuals, clinicians were asked to determine what makes them think an IHTs is useful. Some clinicians reported that in order

for an IHT to be considered useful it should provide new benefits that were not gained using the regular care (*relative advantage*).

> *"I think what I've said before, if this fulfills an unmet need so a need that you know there's a vacancy that this can provide information that is not currently being relayed and that information will change patient care."*
>
> *(Clinician 6, physician, pulmonologist)*

5.4.2.4 Effort Expectancy

Most of the clinicians preferred that the IHTs have an easy to navigate interface, but they indicated it as secondary in importance after usefulness. Clinicians acknowledged that any technology becomes easier to use after a period of contact with the interface, so they were willing to use non-user-friendly technologies if they were of benefit.

> *"… it's just like anything where the more you use it then the faster you are anyway." (Clinician 5, nurse/ care coordinator).*

However, only one clinician indicated that the ease of use was the most important aspect for intention to use IHTs. The clinician indicated that for users who are not technologically savvy, use of IHTs will add to their already-high work stress and will force them to abandon looking for required information.

> *"If I can't find something for instance in Epic which I'm not as familiar with because we always use PowerChart then I will call the coordinators who are outpatient who use Epic all of the time and I will be like "oh, I can't find this and do you know what this is" or something like that so I'm pretty easy to*

give up but I'm also not very technologically savvy… I try, I try a little bit and then if I can't find it then I'm like okay, I give up… you want everything now and you want it easy and right in front of you." (Clinician 3, physician assistant).

5.4.2.5 Facilitating Conditions

According to the clinicians, the availability of resources to accompany the deployment of IHTs was stated crucial to the success of the system. Training and the access to a helpdesk was reported as an expectation from the organization, especially when the use is mandatory. It was strongly recommended that the training be conducted by other early adopter clinicians whom they referred to as "super users" instead of system analysts.

"I mean if they were expecting us to use it then I would expect that they would provide you know sufficient training for us to be able to utilize it and not be wasting our time." (Clinician 4, nurse/ care coordinator)

The clinicians believed that the management should create a culture that facilitates the transition to use IHTs. Sometimes the benefit from the system is not clear to new users and it is the mission of the management to sell IHTs to end-users in a clear and concise manner.

"I will use an example... we moved from one system to another and everyone hated it and they didn't see it as a benefit, but they did it because they had to. And now they've adapted it, we are starting to slowly… and this is three years later, we are still finding nuances that improve what we are doing and once every blue moon, they will say 'oh, I wish we had TPMS [a transplant electronic registry that was replaced by the EHR] … that was so much better'

but then when we look at why it was better and we find a way to change it in our current system then that's thought goes away… It really has to do with like I said management buy in and show them how it's going to impact patients" (Clinician 1, nurse/ transplant coordinator)

When asked about the introduction of individual financial incentives (i.e., institutional or third-party reimbursements for performance) to encourage the use of IHTs, clinicians showed a variety of responses. Some clinicians thought that incentives might encourage them to use IHTs more but only if they were proven to be useful and easy to use. However, other clinicians were not concerned about the monetary incentives and considered the use of IHTs as part of their job. The views about monetary incentives differed depending on the voluntariness of the system. Money was considered to be an attractive incentive when the use of the system was voluntary, but not mandatory.

"Money is always nice but that's just going to be… that if you're asking people to do something outside of work definitely money will impact their decision to participate, but to just… if you're changing somebody's workflow, money has nothing to do with it, in my opinion". (Clinician 1, nurse/ transplant coordinator)

5.4.2.6 Summary of Qualitative Results

Clinicians viewed self-management as individualized and it depends on the patient situation, but they always wanted patients to confer with them before making any change in their care. Clinicians considered IHTs to worth the investment as they provide new data and information about patients when they are home, which are unavailable now using current methods. However,

easy to use IHTs that fit with the current workflow of clinicians is crucial. Clinicians varied with regard to the level of detail they preferred in the reports that IHTs provide ranging from summative reports for physicians and advanced practitioners, to detailed reports preferred by care coordinators. Finally, the availability of adequate resources including helpdesk and training may encourage clinicians to adopt IHTs in their practice.

5.4.3 Synthesis of Quantitative and Qualitative Results

A major finding of the qualitative phase was that clinicians were categorized into three distinct groups: physicians, advanced practitioners, and care coordinators. Therefore, the IPMA analyses of the factors from the quantitative phase (clinicians' beliefs about patient self-management, compatibility, facilitating conditions, perceived ease of use, perceived usefulness, and subjective norms) were conducted for the total sample and for each group (Figure 10). The horizontal axis represents the importance of the factor, while the vertical axis represents the performance of the participants with regards to that factor. For example, for the total sample compatibility of the IHT with clinicians' workflow was the most important factor to influence their intention to use. Specifically, for each standard point increase in compatibility, there was 0.57 point increase in intention to use. However, each of the three groups of clinicians rated some factors more important to them than others. Nurses and care coordinators indicated that facilitating conditions, such as training and IT support, followed by compatibility with the workflow and perceived usefulness, were the most important factors influencing their decision to use IHTs. For nurse practitioners and physician assistants, perceived usefulness was the most important factor, followed by the subjective norms (views of their colleagues) in their workplace. However, for physicians and

surgeons, the compatibility of an IHT with their workflow was the highest priority, and almost twice as high compared to the second important factor, perceived usefulness.

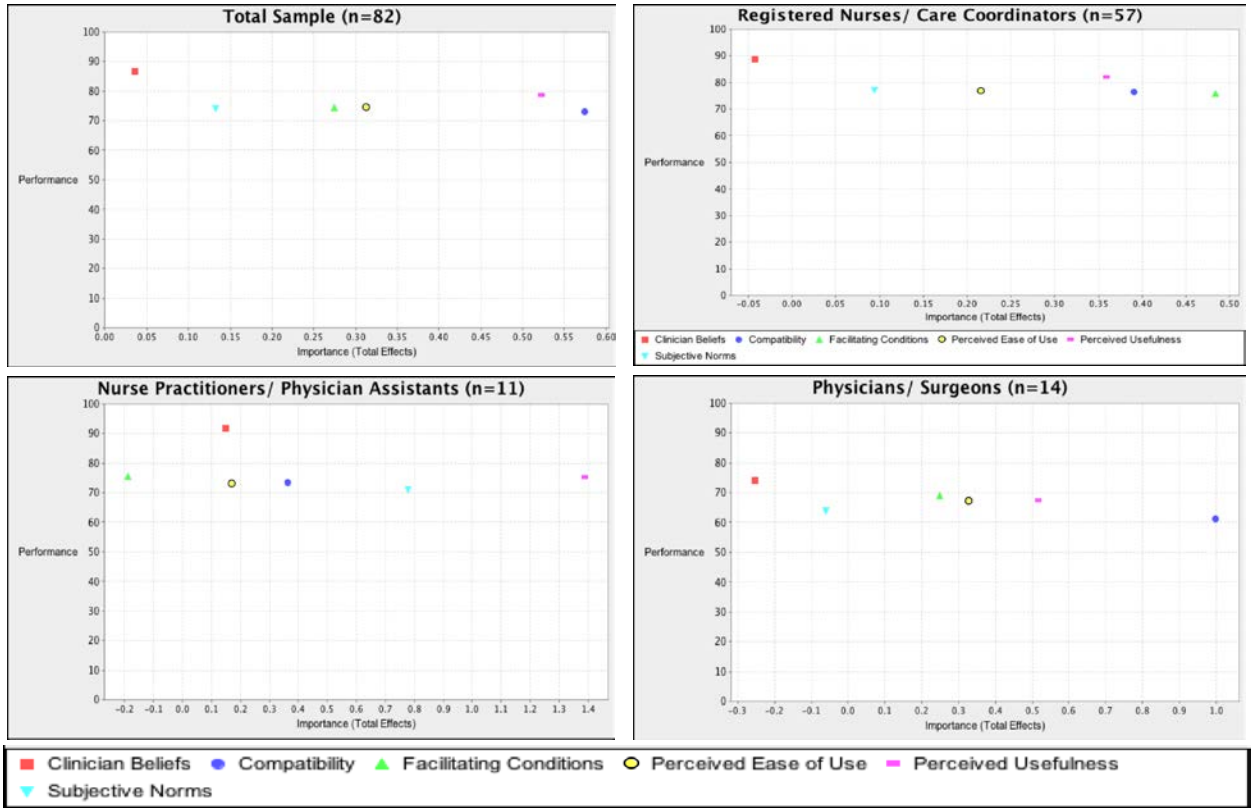

Figure 10. Importance-Performance Map (standardized) for Behavioral Intention to Use IHTs

5.5 DISCUSSION

This mixed-methods study provides a rich description of the factors surrounding clinicians' intention to use IHTs to support patient self-management. Although the present study explored IHTs only among clinicians caring for patients with cardiopulmonary disorders, the results might be generalizable to clinicians caring for other chronic illness populations with similar needs for self-management.

Findings of the qualitative phase confirmed and further explained the quantitative conclusions. While there were congruencies between the findings of both approaches, each of them provided information to complement the gaps in the other inquiry. For example, the analysis of the survey data included the assumption that clinicians should be categorized into two groups (physicians vs. non-physicians). However, the interviews showed that advanced clinicians as a distinct third group in the middle of the spectrum between physicians and care coordinators with regards to accountability about patients and the level of information they are seeking. Accordingly, the mixed-methods analysis included re-analysis of the survey data based on the new knowledge acquired from the qualitative inquiry.

As is typical of mixed-methods designs, congruence of findings between each phase of the study was not the required. While there was some congruence between the findings from both phases, each provided information to complement the gaps that were present in the other inquiry. For example, the analysis of the survey data included the assumption that clinicians should be categorized into two groups (physicians vs. non-physicians). However, the interviews revealed the presence of a third group (advanced practitioners) whose accountability for patient management and the level of information they sought fell between that of physicians and care coordinators. Accordingly, the mixed-methods analysis included re-analysis of the survey data based on the three groups of clinicians that revealed from the qualitative inquiry.

Similar to the survey results, the interviews identified perceived usefulness as the major determinant of intention to use IHTs. Other factors (e.g., perceived ease of use) were less important and were viewed as facilitators for the intention to use IHTs but not to establish it. The study identified different needs for clinicians based on the job responsibilities they held, which was

different from the current approach for deploying and designing IHTs that assumes one-size-fits-all.

5.5.1 Implications

5.5.1.1 IHTs Deployment

The IPMA provides deeper insight into which factors the management should focus on to achieve better results with regard to acceptance and intention to use IHTs. Since nurses and care coordinators are the ones that follow up with patients on a daily basis and thus will use IHTs the most, the availability of hands-on training by other early-adopter clinicians is crucial. Instead, training for nurse practitioner and physician assistants should be more focused on its usefulness in providing enhanced assessments and care delivery for patients. However, for physicians, the management should ensure that the introduction of IHTs does not hinder but rather facilitate their workflow.

5.5.1.2 IHTs Design

Two major design considerations arise from this study. First, the ability of the user interface view to drill down on patient data depends on the role of the clinician and their level of independence and need for details. The higher the level of independence the more summative and concise the interface should be. For instance, physicians should be at first presented with trend views to enable them to look at the macro picture with the capability to quickly locate the details in case they are interested to. However, as reported by one of the care coordinators, nurses tend not trust what is in the electronic system and are worried if they see it there once the information may change later and thus they will not be able to find it again when they go back to check

something. Therefore, the availability of high level of details is crucial to nurses and care coordinators. Second, any future design of IHTs should support sequential reasoning that goes with daily workflow. In other words, the organization and order to the tabs and windows on the screen should reflect the sequence of the routine tasks they perform. This indicates the need for a scalable IHTs that can be tailored to the work performed and the workflow at the site of deployment. Such design enhancements will guide the development of future training courses and the design and development of more user-friendly technologies. Understanding adoption by end-user clinicians will have a significant impact on promoting integration of IHTs' in clinical practice and allow healthcare professionals to reap the fruits of technology for improved patient outcomes.

5.5.2 Limitations

The present study has a few limitations. The small sample selected for interviews may not have adequately represented some clinician groups (physicians and nurse practitioners) and gender (male). In addition, some of the clinicians that were selected for the interviews based on their survey scores did not agree to participate, which also limited the generalizability of the results. Recruiting clinicians, especially physicians, in research studies is challenging and low response rates have been reported when compared to the general population (Cook et al., 2016; Dykema, Jones, Piche, & Stevenson, 2013; Willis, Smith, & Lee, 2013). Nonetheless, saturation was reached and the major themes were confirmed with each type of the included professions. In addition, the study was conducted at one healthcare system. Since many of the factors discussed were related to work environment, the findings might not be applicable to other healthcare systems. However, this study should be recognized for its contributions to understanding clinicians' adoption of IHTs.

5.5.3 Conclusion

The sophisticated structure of healthcare systems and their strong resistance to change is expected to slow the adoption of IHTs unless action is taken to design technological solutions that support the behaviors of the stakeholders in healthcare (PWC, 2012). The engagement of healthcare professionals is pivotal for the adoption of IHTs, and mHealth in general, because technology often forces changes from their standard practice (Broens et al., 2007). Further exploration is needed to identify the features of IHTs that best engage patients in their own care and allow seamless clinician adoption in order to support patient self-management.

APPENDIX A

SURVEY FOR THE QUANTITATIVE PHASE

- **Please answer the following questions about yourself:**

I. What is your email address? _____.

II. What is your gender?

❑ Male ❑ Female

III. What is your age in years?

_____.

IV. What is your highest education level?

❑ Associate's degree ❑ Bachelor's degree ❑ Master's degree

❑ Doctorate/ terminal degree

V. What is your profession?

❑ Physician ❑ Physician Assistant ❑ Nurse Practitioner

❑ Transplant/ Care Coordinator ❑ Registered Nurse

VI. For how many years have you been using (or used) electronic medical records?

_____.

- **Clinicians' Beliefs about Self-Management (J. H. Hibbard et al., 2010):**

		Not at all important	A little important	Somewhat important	Very important
As a clinician, how important is it to you that your patients:					
CBSM1	Are able to take actions that will help prevent or minimize symptoms associated with their health condition.	◯	◯	◯	◯
CBSM2	Are able to work out solutions when new situations or problems arise with their health condition.	◯	◯	◯	◯
CBSM3	Bring a list of questions when they come to the clinic.	◯	◯	◯	◯
CBSM4	Are able to make and maintain lifestyle changes needed to manage their health condition.	◯	◯	◯	◯
CBSM5	Can follow through on medical treatments you told them they need to do at home.	◯	◯	◯	◯
CBSM6	Know what each prescribed medication does.	◯	◯	◯	◯
CBSM7	Able to determine when they need to go to a medical professional for care and when they can manage the problem on their own.	◯	◯	◯	◯
CBSM8	Understand which of their behaviors make their condition better and which ones make it worse.	◯	◯	◯	◯
CBSM9	Understand the different medical treatment options available for their health condition.	◯	◯	◯	◯

CBSM10	Tell you concerns they have about their health even when you do not ask.	◯	◯	◯	◯
CBSM11	Want to be involved as a full partner with you in making decisions about care.	◯	◯	◯	◯
CBSM12	Look for trustworthy sources of information about their health and health choices such as on the web, news, or books.	◯	◯	◯	◯
CBSM13	Want to know what procedures or treatments they will receive and why before the treatments are performed.	◯	◯	◯	◯

- Simulation of Pocket PATH Synergy (illustrative voice over-video and interactive web-portal) was presented at this point of the survey. In addition, screenshots and the software description were available should the participant be unable to access the video on their device.

- **Please answer the following questions based on your viewing of the example about Interactive Health Technologies (IHTs):**

		Strongly disagree (-3)	Disagree (-2)	Slightly disagree (-1)	Neither agree or disagree (0)	Slightly agree (1)	Agree (2)	Strongly agree (3)
Compatibility:								
COM1	Using IHT would be compatible with all aspects of my work.	◯	◯	◯	◯	◯	◯	◯
COM2	I think that using IHT would fit well with the way I like to work.	◯	◯	◯	◯	◯	◯	◯
COM3	Using IHT would fit into my work style.	◯	◯	◯	◯	◯	◯	◯
Perceived Usefulness:								
PU1	Using IHT would improve my performance of patient care and sharing health information.	◯	◯	◯	◯	◯	◯	◯
PU2	Using IHT in my job would increase my productivity of patient care and sharing health information.	◯	◯	◯	◯	◯	◯	◯

		Strongly disagree (-3)	Disagree (-2)	Slightly disagree (-1)	Neither agree or disagree (0)	Slightly agree (1)	Agree (2)	Strongly agree (3)
PU3	Using IHT would enhance my effectiveness of patient care and sharing health information.	◯	◯	◯	◯	◯	◯	◯
PU4	I would find IHT to be useful in my job.	◯	◯	◯	◯	◯	◯	◯
Perceived Ease of Use:								
PEOU1	My interaction with IHT would be clear and understandable.	◯	◯	◯	◯	◯	◯	◯
PEOU2	Interacting with IHTs would not require a lot of my mental effort.	◯	◯	◯	◯	◯	◯	◯
PEOU3	I would find IHT to be easy to use.	◯	◯	◯	◯	◯	◯	◯
PEOU4	I would find it easy to get IHT to do what I want it to do.	◯	◯	◯	◯	◯	◯	◯
Subjective Norm:								
SN1	People who influence my clinical practice would think that I should use IHT.	◯	◯	◯	◯	◯	◯	◯

		Strongly disagree (-3)	Disagree (-2)	Slightly disagree (-1)	Neither agree or disagree (0)	Slightly agree (1)	Agree (2)	Strongly agree (3)
SN2	People who are important to me at workplace would think that I should use IHT.	◯	◯	◯	◯	◯	◯	◯
SN3	The senior management of my workplace would be helpful in the use of IHT.	◯	◯	◯	◯	◯	◯	◯
SN4	In general, I think my organization would support the use of IHT.	◯	◯	◯	◯	◯	◯	◯
Facilitating Conditions:								
FC1	I would have the resources necessary to use IHT at my workplace.	◯	◯	◯	◯	◯	◯	◯
FC2	I think technical assistance about IHT would be available when necessary.	◯	◯	◯	◯	◯	◯	◯
FC3	I would have the knowledge to make use of IHT in my practice.	◯	◯	◯	◯	◯	◯	◯

		Strongly disagree (-3)	Disagree (-2)	Slightly disagree (-1)	Neither agree or disagree (0)	Slightly agree (1)	Agree (2)	Strongly agree (3)
Voluntariness:								
VOL1	I think my use of IHT would be voluntary at my workplace.	○	○	○	○	○	○	○
VOL2	I think my supervisor would not require me to use IHT.	○	○	○	○	○	○	○
VOL3	Although it might be helpful, using IHT would not certainly be compulsory in my job.	○	○	○	○	○	○	○
Behavioral Intention to Use:								
BIU1	Assuming I had access to IHT, I intend to use it.	○	○	○	○	○	○	○
BIU2	Given that I had access to IHT, I predict that I would use it.	○	○	○	○	○	○	○
BIU3	I plan to use IHT in the future.	○	○	○	○	○	○	○

APPENDIX B

SEMI-STRUCTURED INTERVIEW GUIDE FOR THE QUALITATIVE PHASE

Interview Guide

After the introduction, each of the following sections will start with general questions to allow the participants the opportunity to freely express their opinions. Next, more specific questions were asked to fill in the gaps in the responses. The questions included here represent the general frame of what was asked in the interview, however, the ultimate list of questions were finalized after the quantitative part (phase I).

1) **Interview Introduction:**

   In this section, general information was obtained and transmitted as following:

   a. Remind the participants of the topic of the interview.
   b. Inform the participants that the interview will be audiotaped and when the content is transcribed, the recordings will be deleted.
   c. Assure them that the information gathered will be kept confidential and no names will be used in the transcription.
   d. Confirm that I am merely interested in their perspectives and there are no right or wrong responses.
   e. Double check if they wish to continue to participate in the interview and remind them that they can withdraw participation at any point during the interview.

2) **Beliefs about self-management**

   a. Tell me about your clinical experience and the population of patients you care for.
   b. Can you describe what it means for patients to be actively involved in their care? What about patient self-management? How important do you consider these behaviors on the part of patients? What role do clinicians play in these patient behaviors?

c. What does it mean for patients to self-manage their illness?

d. What role do you believe that patients have in clinical management? (e.g., following your medical recommendations? seeking information on their own, bring questions to you? evaluating available treatment options? or making independent judgments and decisions)? These questions were asked separately if they do not include these in their response. Why?

e. What led you to hold such views of patient self-management?

f. What role do you believe clinicians have in promoting patient self-management?

3) Factors affecting the uptake of IHTs:

After asking general questions about support for patient activation, participants were reminded of the definition of IHTs. Then we ask the following questions were asked:

a) Compatibility:

a. How do you think using IHTs (such as the sample you were shown) fit with your work style? Fit into your workflow?

b. What factors are barriers to fitting IHTs into your lifestyle? Your workflow?

c. What factors might facilitate better fitting?

b) Ease of Use:

a. How easy to use do you think using IHTs are or will be?

b. How important are previous technology experience and general computer mastery skills for use of such systems?

c. If you have ever used IHTs, in what context were they used in and how easy did you find them to use?

d. Which one do you think will impact your perspective about the ease of using an IHT, the characteristics of the technology, such as usability, or your degree of confidence and mastery in using computer technologies in general? Why?

c) Perceived Usefulness:

a. How useful do you think IHTs will be? How might they affect your productivity and job performance?

b. If you have ever used an IHT, in what context were they used and how useful did you find them?

c. What do you think will make an IHT more or less useful?

d) Subjective Norm:

a. How do you think your colleagues' perspectives about the use of IHTs will impact your perspectives?

b. How voluntary you expect that IHT usage will be in your work setting?

c. How would you consider your colleagues' perspectives given that the expected use of the system was mandatory/ voluntary (the opposite of what was answered in the previous question)?

e) Facilitating conditions:

a. How supportive do you think your organization will be with regards to technical assistance? training to use IHTs? And monetary incentives?

b. What would be the influence degree of providing monetary incentives on your decision to use IHTs?

4) Importance of factors:

a. Of all the factors impacting the decision to use IHTs or not, which ones do you think are the most important? Can you tell me more about that?

5) Interview conclusion:

a. Are there any additional comments you wish to add?

b. Would you like to hear about the results of the study when it is concluded?

c. Thank you!

APPENDIX C

HUMAN SUBJECTS APPROVALS AND CONSENTS

University of Pittsburgh
Institutional Review Board

3500 Fifth Avenue
Pittsburgh, PA 15213
(412) 383-1480
(412) 383-1508 (fax)
http://www.irb.pitt.edu

Memorandum

To: Mohammad Alrawashdeh , MSN
From: IRB Office
Date: 3/24/2017
IRB#: PRO16040645
Subject: Clinicians' Acceptance of Interactive Health Technologies to Support Patient Self-Management

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The University of Pittsburgh Institutional Review Board reviewed and approved the above referenced study by the expedited review procedure authorized under 45 CFR 46.110 and 21 CFR 56.110. Your research study was approved under:

45 CFR 46.110.(6)
45 CFR 46.110.(7)

The IRB has approved the waiver for the requirement to obtain a written informed consent for all subjects and all procedures.

The risk level designation is Minimal Risk.

Approval Date: 3/24/2017
Expiration Date: 3/23/2020

This study meets the criteria for an extended approval period of three years. In the event that any type of federal funding is obtained during this interval, a modification must be submitted immediately so the IRB can reassess the approval period.

For studies being conducted in UPMC facilities, no clinical activities can be undertaken by investigators until they have received approval from the UPMC Fiscal Review Office.

Please note that it is the investigator's responsibility to report to the IRB any unanticipated problems involving risks to subjects or others [see 45 CFR 46.103(b)(5) and 21 CFR 56.108(b)]. Refer to the IRB Policy and Procedure Manual regarding the reporting requirements for unanticipated problems which include, but are not limited to, adverse events. If you have any questions about this process, please contact the Adverse Events Coordinator at 412-383-1480.

The protocol and consent forms, along with a brief progress report must be resubmitted at least one month prior to the renewal date noted above as required by FWA00006790 (University of Pittsburgh), FWA00006735 (University of Pittsburgh Medical Center), FWA00000600 (Children's Hospital of Pittsburgh), FWA00003567 (Magee-Womens Health Corporation), FWA00003338 (University of Pittsburgh Medical Center Cancer Institute).

Please be advised that your research study may be audited periodically by the University of Pittsburgh Research Conduct and Compliance Office.

BIBLIOGRAPHY

Aggelidis, V. P., & Chatzoglou, P. D. (2009). Using a modified technology acceptance model in hospitals. *Int J Med Inform, 78*, 115-126. doi:10.1016/j.ijmedinf.2008.06.006

Ajzen, I., Netemeyer, R., & Ryn, M. V. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179-211. doi:http://dx.doi.org/10.1016/0749-5978(91)90020-T

Alexander, J. A., Hearld, L. R., Mittler, J. N., & Harvey, J. (2012). Patient-physician role relationships and patient activation among individuals with chronic illness. *Health Serv Res, 47*(3 Pt 1), 1201-1223. doi:10.1111/j.1475-6773.2011.01354.x

Allen, M., Mann, K., Putnam, W., Richard, J., Carr, C., Pottle, K., & Sargeant, J. (2000). Prescribing exercise for cardiac patients: knowledge, practices, and needs of family physicians and specialists. *J Cardiopulm Rehabil, 20*(6), 333-339.

Alvarez, C., Greene, J., Hibbard, J., & Overton, V. (2016). The role of primary care providers in patient activation and engagement in self-management: a cross-sectional analysis. *BMC Health Serv Res, 16*(1), 85. doi:10.1186/s12913-016-1328-3

Ando, K., Yorifuji, K., Ohnuma, S., Matthies, E., & Kanbara, A. (2015). Transmitting pro-environmental behaviours to the next generation: A comparison between Germany and Japan. *Asian Journal of Social Psychology, 18*(2), 134-144. doi:10.1111/ajsp.12078

Asua, J., Orruño, E., Reviriego, E., Gagnon, M. P. M. P., & Orruno, E. (2012). Healthcare professional acceptance of telemonitoring for chronic care patients in primary care. *BMC Medical Informatics and Decision Making, 12*, 139. doi:10.1186/1472-6947-12-139

atlasti.com. (2017). ATLAS.ti [Computer Software] (Version 1.6.0, Mac). Berlin, Germany. Retrieved from http://www.atlasti.com/

Banerjee, A. T., Grace, S. L., Thomas, S. G., & Faulkner, G. (2010). Cultural factors facilitating cardiac rehabilitation participation among Canadian South Asians: a qualitative study. *Heart Lung, 39*(6), 494-503. doi:10.1016/j.hrtlng.2009.10.021

Barriball, K. L., & While, A. (1994). Collecting data using a semi-structured interview: a discussion paper. *J Adv Nurs, 19*(2), 328-335.

Beck, C. T. (1993). Teetering on the edge: a substantive theory of postpartum depression. *Nursing research, 42*, 42-48.

Berg, M. (2001). Implementing information systems in health care organizations: myths and challenges. *International Journal of Medical Informatics, 64*, 143-156.

Bidwell, J. T., Vellone, E., Lyons, K. S., D'Agostino, F., Riegel, B., Juarez-Vela, R., . . . Lee, C. S. (2015). Determinants of Heart Failure Self-Care Maintenance and Management in Patients and Caregivers: A Dyadic Analysis. *Res Nurs Health, 38*(5), 392-402. doi:10.1002/nur.21675

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation? *Qual Health Res*. doi:10.1177/1049732316654870

Bishop, T. F., Press, M. J., Mendelsohn, J. L., & Casalino, L. P. (2013). Electronic communication improves access, but barriers to its widespread adoption remain. *Health Affairs, 32*, 1361-1367. doi:10.1377/hlthaff.2012.1151

Bitsaki, M., Koutras, C., Koutras, G., Leymann, F., Steimle, F., Wagner, S., & Wieland, M. (2016). ChronicOnline: Implementing a mHealth solution for monitoring and early alerting in chronic obstructive pulmonary disease. *Health Informatics J*. doi:10.1177/1460458216641480

Bohm, M., Robertson, M., Ford, I., Borer, J. S., Komajda, M., Kindermann, I., . . . Tavazzi, L. (2015). Influence of Cardiovascular and Noncardiovascular Co-morbidities on Outcomes and Treatment Effect of Heart Rate Reduction With Ivabradine in Stable Heart Failure (from the SHIFT Trial). *Am J Cardiol, 116*(12), 1890-1897. doi:10.1016/j.amjcard.2015.09.029

Boonstra, A., & Broekhuis, M. (2010). Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions. *BMC health services research, 10*, 231. doi:10.1186/1472-6963-10-231

Bossen, C., Jensen, L. G., & Udsen, F. W. (2013). Evaluation of a comprehensive EHR based on the DeLone and McLean model for IS success: Approach, results, and success factors.

International Journal of Medical Informatics, 2, 940-953. doi:10.1016/j.ijmedinf.2013.05.010

Braunstein, J. B., Anderson, G. F., Gerstenblith, G., Weller, W., Niefeld, M., Herbert, R., & Wu, A. W. (2003). Noncardiac comorbidity increases preventable hospitalizations and mortality among Medicare beneficiaries with chronic heart failure. *Journal of the American College of Cardiology, 42*(7), 1226-1233.

Broens, T. H. F., Huis in't Veld, R. M. H. a., Vollenbroek-Hutten, M. M. R., Hermens, H. J., van Halteren, A. T., & Nieuwenhuis, L. J. M. (2007). Determinants of successful telemedicine implementations: a literature study. *Journal of telemedicine and telecare, 13*, 303-309. doi:10.1258/135763307781644951

Brown, J. (2011). Likert items and scales of measurement. *Shiken: JALT Testing & Evaluation SIG Newsletter, 15*, 10-14.

Burton-Jones, A., & Gallivan, M. J. (2007). Toward a Deeper Understanding of System Usage in Organizations: A Multilevel Perspective. *MIS quarterly, 31*(4), 657-679.

Centers for Disease Control and Prevention. (2015). Chronic Diseases: The Leading Causes of Death and Disability in the United States. Retrieved from http://www.cdc.gov/chronicdisease/overview/

Centers for Disease control and Prevention. (2017). Chronic Disease Overview. Retrieved from https://www.cdc.gov/chronicdisease/overview/index.htm

Chatterji, A. K., Fabrizio, K. R., Mitchell, W., & Schulman, K. a. (2008). Physician-industry cooperation in the medical device industry. *Health affairs (Project Hope), 27*, 1532-1543. doi:10.1377/hlthaff.27.6.1532

Chau, P. Y. K., & Hu, P. J. (2002). Examining a Model of Information Technology Acceptance by Individual Professionals: An Exploratory Study. *Journal of Management Information Systems, 18*(4), 191-229.

Chau, P. Y. K., & Hu, P. J.-H. (2002). Investigating healthcare professionals' decisions to accept telemedicine technology: an empirical test of competing theories. *Information & Management, 39*, 297-311. doi:10.1016/S0378-7206(01)00098-2

Chau, P. Y. K., & Hu, P. J. H. (2001). Information Technology Acceptance by Individual Professionals: A Model Comparison Approach. *Decision Sciences, 32*, 699-719. doi:10.1111/j.1540-5915.2001.tb00978.x

Clark, A. M., King-Shier, K. M., Duncan, A., Spaling, M., Stone, J. A., Jaglal, S., & Angus, J. (2013). Factors influencing referral to cardiac rehabilitation and secondary prevention programs: a systematic review. *Eur J Prev Cardiol, 20*(4), 692-700. doi:10.1177/2047487312447846

Conner, M., & Armitage, C. J. (1998). Extending the Theory of Planned Behavior: A Review and Avenues for Further Research. *Journal of Applied Social Psychology, 28*, 1429-1464. doi:10.1111/j.1559-1816.1998.tb01685.x

Cook, D. A., Wittich, C. M., Daniels, W. L., West, C. P., Harris, A. M., & Beebe, T. J. (2016). Incentive and Reminder Strategies to Improve Response Rate for Internet-Based Physician Surveys: A Randomized Experiment. *J Med Internet Res, 18*(9), e244. doi:10.2196/jmir.6318

Creswell, J. J. W., Klassen, A. C. A., Plano Clark, V. L. V., & Smith, K. C. K. (2011). Best practices for mixed methods research in the health sciences. *Bethesda (Maryland): National Institutes of Health*.

Currie, G., & White, L. (2012). Inter-professional Barriers and Knowledge Brokering in an Organizational Context: The Case of Healthcare. *Organization Studies, 33*(10), 1333-1361. doi:10.1177/0170840612457617

Dabbs, A. D. V., Kim, Y., Hamdan-Mansour, A., Thibodeau, A., & Curry, K. M. (2006). Health Locus of Control After Lung Transplantation: Implications for Managing Health. *Journal of clinical psychology in medical settings, 13*(4), 378-389. doi:10.1007/s10880-006-9038-3

Davies, C. (2000). Getting health professionals to work together. *BMJ, 320*(7241), 1021-1022.

Davis, F. D. (1986). *A technology acceptance model for empirically testing new end-user information systems: Theory and results.* (Ph.D.), Massachusetts Institute of Technology, Sloan School of Management.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly, 13*, 319-340.

Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. *International Journal of ManMachine Studies, 38*, 475-487. doi:10.1006/imms.1993.1022

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science, 35*, 982-1003. doi:10.1287/mnsc.35.8.982

De Vito Dabbs, A., Myers, B. A., Mc Curry, K. R., Dunbar-Jacob, J., Hawkins, R. P., Begey, A., & Dew, M. A. (2009). User-centered design and interactive health technologies for patients. *Comput Inform Nurs, 27*(3), 175-183. doi:10.1097/NCN.0b013e31819f7c7c

de Vries, S. T., Wong, L., Sutcliffe, A., Houÿez, F., Ruiz, C. L., Mol, P. G. M., . . . Afzal, F. (2017). Factors Influencing the Use of a Mobile App for Reporting Adverse Drug Reactions and Receiving Safety Information: A Qualitative Study. *Drug Safety, 40*(5), 443-455. doi:10.1007/s40264-016-0494-x

DeLone, W. H., & Mclean, E. R. (2003). The DeLone and McLean model of information systems success: a ten-year update. *Journal of Management Information Systems, 19*, 9-30. doi:10.1073/pnas.0914199107

Department of Health and Human Services, H. R. a. S. A., Healthcare Systems Bureau, Division of Transplantation, Rockville, MD; United Network for Organ Sharing, Richmond, VA; University Renal Research and Education Association Ann Arbor, MI. (2012). *2012 Annual Report of the U.S. Organ Procurement and Transplantation Network and the Scientific Registry of Transplant Recipients: Transplant Data 1998-2012*. Retrieved from

DeVito Dabbs, A., Dew, M. A., Myers, B., Begey, A., Hawkins, R., Ren, D., . . . McCurry, K. R. (2009). Evaluation of a hand-held, computer-based intervention to promote early self-care behaviors after lung transplant. *Clin Transplant, 23*(4), 537-545. doi:10.1111/j.1399-0012.2009.00992.x

DeVito Dabbs, A., Song, M. K., Myers, B. A., Li, R., Hawkins, R. P., Pilewski, J. M., . . . Dew, M. A. (2016). A Randomized Controlled Trial of a Mobile Health Intervention to Promote Self-Management After Lung Transplantation. *Am J Transplant, 16*(7), 2172-2180. doi:10.1111/ajt.13701

Doll, W. J., & Torkzadeh, G. (1998). Developing a multidimensional measure of system-use in an organizational context. *Information & Management, 33*(4), 171-185. doi:http://dx.doi.org/10.1016/S0378-7206(98)00028-7

Dwivedi, Y. K., Wade, M. R., & Schneberger, S. L. (2011). *Information Systems Theory: Explaining and Predicting Our Digital Society*: Springer New York.

Dykema, J., Jones, N. R., Piche, T., & Stevenson, J. (2013). Surveying clinicians by web: current issues in design and administration. *Eval Health Prof, 36*(3), 352-381. doi:10.1177/0163278713496630

Effing, T., Monninkhof, E. M., van der Valk, P. D., van der Palen, J., van Herwaarden, C. L., Partidge, M. R., . . . Zielhuis, G. A. (2007). Self-management education for patients with chronic obstructive pulmonary disease. *Cochrane Database Syst Rev*(4), CD002990. doi:10.1002/14651858.CD002990.pub2

Fetters, M. D., Curry, L. a., & Creswell, J. W. (2013). Achieving integration in mixed methods designs-principles and practices. *Health services research, 48*, 2134-2156. doi:10.1111/1475-6773.12117

Fisbein, M., & Ajzen, I. (1975). Belief, attitude, intention and behavior: an introduction to theory and research. *Massachusetts, Addison-Wiley Publishing Company*.

Flodgren, G., Rachas, A., Farmer, A. J., Inzitari, M., & Shepperd, S. (2015). Interactive telemedicine: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev, 9*, CD002098. doi:10.1002/14651858.CD002098.pub2

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research, 18*(1). doi:10.2307/3151312

Gagnon, M.-P., Ghandour, E. K., Talla, P. K., Simonyan, D., Godin, G., Labrecque, M., . . . Rousseau, M. (2013). Electronic Health Record Acceptance by Physicians: Testing an Integrated Theoretical Model. *Journal of biomedical informatics*. doi:10.1016/j.jbi.2013.10.010

Gagnon, M.-P., Godin, G., Gagné, C., Fortin, J.-P., Lamothe, L., Reinharz, D., & Cloutier, A. (2003). An adaptation of the theory of interpersonal behaviour to the study of telemedicine adoption by physicians. *International Journal of Medical Informatics, 71*(2-3), 103-115. doi:10.1016/s1386-5056(03)00094-7

Gagnon, M. P., Desmartis, M., Labrecque, M., Car, J., Pagliari, C., Pluye, P., . . . Legare, F. (2012). Systematic review of factors influencing the adoption of information and communication

technologies by healthcare professionals. *J Med Syst, 36*(1), 241-277. doi:10.1007/s10916-010-9473-4

Gagnon, M. P., Ngangue, P., Payne-Gagnon, J., & Desmartis, M. (2016). m-Health adoption by healthcare professionals: a systematic review. *J Am Med Inform Assoc, 23*(1), 212-220. doi:10.1093/jamia/ocv052

Gagnon, M. P., Orruno, E., Asua, J., Abdeljelil, A. B., & Emparanza, J. (2012). Using a modified technology acceptance model to evaluate healthcare professionals' adoption of a new telemonitoring system. *Telemed J E Health, 18*(1), 54-59. doi:10.1089/tmj.2011.0066

Geersing, G. J., de Groot, J. A., Reitsma, J. B., Hoes, A. W., & Rutten, F. H. (2015). The impending epidemic of chronic cardiopulmonary disease and multimorbidity: the need for new research approaches to guide daily practice. *Chest, 148*(4), 865-869. doi:10.1378/chest.14-3172

Goldstein, C. M., Gathright, E. C., Dolansky, M. A., Gunstad, J., Sterns, A., Redle, J. D., . . . Hughes, J. W. (2014). Randomized controlled feasibility trial of two telemedicine medication reminder systems for older adults with heart failure. *Journal of telemedicine and telecare, 20*, 293-299. doi:10.1177/1357633x14541039

Grypdonck, M. (1997). Importance of qualitative research for nursing and nursing science. *Pflege, 10*, 222-228.

Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. Thousand Oaks, Calif.: Sage Publications.

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a Silver Bullet. *Journal of Marketing Theory and Practice, 19*(2), 139-152. doi:10.2753/MTP1069-6679190202

Hair Jr, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)* (2nd ed.). Thousand Oaks: Sage Publications.

Hawkins, N. M., Virani, S., & Ceconi, C. (2013). Heart failure and chronic obstructive pulmonary disease: the challenges facing physicians and health services. *Eur Heart J, 34*(36), 2795-2803. doi:10.1093/eurheartj/eht192

Heid, H. G., & Schmelzer, M. (2004). Influences on women's participation in cardiac rehabilitation. *Rehabil Nurs, 29*(4), 116-121.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2014). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115-135. doi:10.1007/s11747-014-0403-8

Heron, M. (2016). Deaths: Leading Causes for 2013. *Natl Vital Stat Rep, 65*(2), 1-95.

Hibbard, J. H., Collins, P. A., Mahoney, E., & Baker, L. H. (2010). The development and testing of a measure assessing clinician beliefs about patient self-management. *Health Expect, 13*(1), 65-72. doi:10.1111/j.1369-7625.2009.00571.x

Hibbard, J. H., Mahoney, E. R., Stock, R., & Tusler, M. (2007). Do increases in patient activation result in improved self-management behaviors? *Health services research, 42*, 1443-1463. doi:10.1111/j.1475-6773.2006.00669.x

Hikmet, N., & Chen, S. K. (2003). An investigation into low mail survey response rates of information technology users in health care organizations. *International Journal of Medical Informatics, 72*, 29-34.

Hirose, M., & Tabe, K. (2016). Responses to Mhealth Application on Health Behavior: A Theoretical Extension of the Technology Acceptance Model *Looking Forward, Looking Back: Drawing on the Past to Shape the Future of Marketing* (pp. 46-55).

Hock, C., Ringle, C. M., & Sarstedt, M. (2010). Management of multi-purpose stadiums: Importance and performance measurement of service interfaces. *International Journal of Services Technology and Management, 14*(2-3), 188-207.

Holden, R. J., & Karsh, B.-T. T. (2010). The technology acceptance model: its past and its future in health care. *Journal of biomedical informatics, 43*, 159-172. doi:10.1016/j.jbi.2009.07.002

Hong, S., Thong, J. Y. L., & Tam, K. Y. (2006). Understanding continued information technology usage behavior: A comparison of three models in the context of mobile internet. *Decision Support Systems, 42*(3), 1819-1834. doi:10.1016/j.dss.2006.03.009

Hu, P. J. P., Chau, P. Y. K. P., Liu Sheng, O. R., Tam, K. Y. A. R. Y. A. N., & Sheng, O. R. L. I. U. (1999). Examining the Technology Acceptance Model Using Physician Acceptance of Telemedicine Technology. *Journal of Management Information Systems, 16*, 91-112.

Hung, S.-Y., Tsai, J. C.-A., & Chuang, C.-C. (2014). Investigating primary health care nurses' intention to use information technology: An empirical study in Taiwan. *Decision Support Systems, 57*, 331-342. doi:10.1016/j.dss.2013.09.016

Hutcheson, G. D., & Sofroniou, N. (1999). *The Multivariate Social Scientist: Introductory Statistics Using Generalized Linear Models*. London ; Thousand Oaks, Calif.: SAGE Publications.

Hwang, S. (2007). Utilizing Qualitative Data Analysis Software: A Review of Atlas.ti. *Social Science Computer Review, 26*(4), 519-527. doi:10.1177/0894439307312485

Insignia Health. (2010). Clinician Activation Measure: License Material. Retrieved from https://www.insigniahealth.com/

Janssen, C. (2014). Mobile Application (Mobile App). Retrieved from https://www.techopedia.com/definition/2953/mobile-application-mobile-app

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. *Educational Researcher, 33*(7), 14-26.

Jung, M.-L., & Loria, K. (2010). Acceptance of Swedish e-health services. *Journal of multidisciplinary healthcare, 3*, 55-63. doi:10.2147/JMDH.S9159

Jörskog, K., & Wold, H. (1982). The ML and PLS Techniques for Modeling With Latent Variables: Historical and Comparitive Aspects. *Systems Under Indirect Observation: Part I*, 263-270.

Kim, H. S., Choi, W., Baek, E. K., Kim, Y. A., Yang, S. J., Choi, I. Y., . . . Cho, J. H. (2014). Efficacy of the smartphone-based glucose management application stratified by user satisfaction. *Diabetes & Metabolism Journal, 38*, 204-210. doi:10.4093/dmj.2014.38.3.204

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. *Information & Management, 43*(6), 740-755. doi:10.1016/j.im.2006.05.003

Kollmann, A., Riedl, M., Kastner, P., Schreier, G., & Ludvik, B. (2007). Feasibility of a mobile phone-based data service for functional insulin treatment of type 1 diabetes mellitus patients. *Journal of Medical Internet Research, 9*, e36. doi:10.2196/jmir.9.5.e36

Kuhn, E., Eftekhari, A., Hoffman, J. E., Crowley, J. J., Ramsey, K. M., Reger, G. M., & Ruzek, J. I. (2014). Clinician Perceptions of Using a Smartphone App with Prolonged Exposure Therapy. *Administration and policy in mental health*. doi:10.1007/s10488-013-0532-2

Kumar, S., Nilsen, W., Pavel, M., & Srivastava, M. (2013). Mobile Health : Revolutionizing Healthcare Through Transdisciplinary Research. *IEEE Computer Society, 46*, 28-35.

Laerum, H., Ellingsen, G., & Faxvaag, A. (2001). Doctors' use of electronic medical records systems in hospitals: cross sectional survey. *BMJ British Medical Journal, 323*, 1344-1348.

Langdridge, D., Sheeran, P., & Connolly, K. J. (2007). Analyzing additional variables in the theory of reasoned action. *Journal of Applied Social Psychology, 37*, 1884-1913.

Lanseng, E. J., & Andreassen, T. W. (2007). Electronic healthcare: a study of people's readiness and attitude toward performing self-diagnosis. *International Journal of Service Industry Management, 18*, 394-417. doi:10.1108/09564230710778155

Lapointe, L., & Rivard, S. (2005). A Multilevel Model of Resistance to Information Technology Implementation. *MIS quarterly, 29*, 461-491.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management, 40*, 191-204. doi:10.1016/S0378-7206(01)00143-4

Levy, D., Kenchaiah, S., Larson, M. G., Benjamin, E. J., Kupka, M. J., Ho, K. K., . . . Vasan, R. S. (2002). Long-term trends in the incidence of and survival with heart failure. *N Engl J Med, 347*(18), 1397-1402. doi:10.1056/NEJMoa020265

Li, J., Talaei-Khoei, A., Seale, H., Ray, P., & Macintyre, C. R. (2013). Health Care Provider Adoption of eHealth: Systematic Literature Review. *Interactive journal of medical research, 2*, e7. doi:10.2196/ijmr.2468

Lieberman, L., Meana, M., & Stewart, D. (1998). Cardiac rehabilitation: gender differences in factors influencing participation. *J Womens Health, 7*(6), 717-723.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, Calif.: Sage Publications.

Lorig, K. R., & Holman, H. R. (2003). Self-Management Education: History, Definition, Outcomes, and Mechanisms. *Annals of Behavioral Medicine, 26*, 1-7.

Lundell, S., Holmner, A., Rehn, B., Nyberg, A., & Wadell, K. (2015). Telehealthcare in COPD: a systematic review and meta-analysis on physical outcomes and dyspnea. *Respir Med, 109*(1), 11-26. doi:10.1016/j.rmed.2014.10.008

Markus, M. L. (1983). Power, politics, and MIS implementation. *Communications of the ACM, 26*, 430-444. doi:10.1145/358141.358148

Mathieson, K. (1991). Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior. *Information Systems Research, 2*, 173-191. doi:10.1287/isre.2.3.173

McDermott, M. S., & While, A. E. (2013). Maximizing the healthcare environment: A systematic review exploring the potential of computer technology to promote self-management of chronic illness in healthcare settings. *Patient Education and Counseling, 92*, 13-22. doi:10.1016/j.pec.2013.02.014

McSweeney, J. C., & Crane, P. B. (2001). An act of courage: women's decision-making processes regarding outpatient cardiac rehabilitation attendance. *Rehabil Nurs, 26*(4), 132-140.

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Reprint--preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Physical therapy, 89*, 873-880.

Moore, G. C., & Benbasat, I. (1991). Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research, 2*, 192-222. doi:10.1287/isre.2.3.192

National Institute of Health. (2013). mHealth - Mobile Health Technologies.

Neubeck, L., Freedman, S. B., Clark, A. M., Briffa, T., Bauman, A., & Redfern, J. (2012). Participating in cardiac rehabilitation: a systematic review and meta-synthesis of qualitative data. *Eur J Prev Cardiol, 19*(3), 494-503.

Ngai, E. W. T., Poon, J. K. L., & Chan, Y. H. C. (2007). Empirical examination of the adoption of WebCT using TAM. *Computers & Education, 48*, 250-267. doi:10.1016/j.compedu.2004.11.007

NHS England. (2015). How much do clinicians support patient activation?

Nielsen, J. (2012). Mobile Sites vs. Apps: The Coming Strategy Shift. Retrieved from https://www.nngroup.com/articles/mobile-sites-vs-apps-strategy-shift/

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw-Hill.

Okazaki, S., Castaneda, J. A., Sanz, S., & Henseler, J. (2012). Factors affecting mobile diabetes monitoring adoption among physicians: questionnaire study and path model. *J Med Internet Res, 14*(6), e183. doi:10.2196/jmir.2159

Or, C. K., & Karsh, B. T. (2009). A systematic review of patient acceptance of consumer health information technology. *J Am Med Inform Assoc, 16*(4), 550-560. doi:10.1197/jamia.M2888

Orlikowski, W., & Hoffman, D. (1997). An Imporvisational Model for Change Managment: The Case of Groupware Technologies. *Inventing the Organizations of the 21st Century, MIT, Boston, MA,* 265-282.

Orruno, E., Gagnon, M. P., Asua, J., Ben Abdeljelil, A., & Orruño, E. (2011). Evaluation of teledermatology adoption by health-care professionals using a modified Technology Acceptance Model. *J Telemed Telecare, 17*, 303-307. doi:10.1258/jtt.2011.101101

Penttinen, E., Rinta-Kahila, T., Ronkko, M., & Saarinen, T. (2014). Triggering Intention to Use to Actual Use -- Empirical Evidence from Self-Service Checkout (SCO) Systems. 3347-3355. doi:10.1109/hicss.2014.414

Perugini, M., & Bagozzi, R. P. (2001). The role of desires and anticipated emotions in goal-directed behaviours: broadening and deepening the theory of planned behaviour. *Br J Soc Psychol, 40*(Pt 1), 79-98.

Petter, S., DeLone, W., & McLean, E. (2008). Measuring information systems success: models, dimensions, measures, and interrelationships. *European Journal of Information Systems, 17*, 236-263. doi:10.1057/ejis.2008.15

Petter, S., DeLone, W., & McLean, E. R. (2013). Information Systems Success: The Quest for the Independent Variables. *Journal of Management Information Systems, 29*, 7-62. doi:10.2753/MIS0742-1222290401

Pluye, P., Gagnon, M. P., Griffiths, F., & Johnson-Lafleur, J. (2009). A scoring system for appraising mixed methods research, and concomitantly appraising qualitative, quantitative and mixed methods primary studies in Mixed Studies Reviews. *Int J Nurs Stud, 46*(4), 529-546. doi:10.1016/j.ijnurstu.2009.01.009

Polisena, J., Tran, K., Cimon, K., Hutton, B., McGill, S., Palmer, K., & Scott, R. E. (2010). Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta-analysis. *J Telemed Telecare, 16*(3), 120-127. doi:10.1258/jtt.2009.090812

Putzer, G. J., & Park, Y. (2010). The effects of innovation factors on smartphone adoption among nurses in community hospitals. *Perspectives in health information management / AHIMA, American Health Information Management Association, 7*, 1b.

PWC. (2012). Emerging mHealth: Paths for growth. *Price Waterhouse Cooper*.

Qualtrics LLC. (2016). Partial Completion. Retrieved from https://www.qualtrics.com/support/survey-platform/survey-module/survey-options/partial-completion/

Rademakers, J., Jansen, D., van der Hoek, L., & Heijmans, M. (2015). Clinicians' beliefs and attitudes toward patient self-management in the Netherlands; translation and testing of the American Clinician Support for Patient Activation Measure (CS-PAM). *BMC health services research, 15*, 1-7. doi:10.1186/s12913-015-0799-y

Ratanawongsa, N., Bhandari, V. K., Handley, M., Rundall, T., Hammer, H., & Schillinger, D. (2012). Primary Care Provider Perceptions of the Effectiveness of Two Self-Management Support Programs for Vulnerable Patients with Diabetes. *Journal of diabetes science and technology, 6*, 116-124. doi:10.1177/193229681200600114

Rho, M. J., Choi, I. Y., & Lee, J. (2014). Predictive factors of telemedicine service acceptance and behavioral intention of physicians. *Int J Med Inform, 83*(8), 559-571. doi:10.1016/j.ijmedinf.2014.05.005

Riegel, B., Lee, C. S., Dickson, V. V., & Medscape. (2011). Self care in patients with chronic heart failure. *Nat Rev Cardiol, 8*(11), 644-654. doi:10.1038/nrcardio.2011.95

Riegel, B., Moser, D. K., Anker, S. D., Appel, L. J., Dunbar, S. B., Grady, K. L., . . . Whellan, D. J. (2009). State of the science: promoting self-care in persons with heart failure: a scientific statement from the American Heart Association. *Circulation, 120*, 1141-1163. doi:10.1161/CIRCULATIONAHA.109.192628

Riley, W. T., Rivera, D. E., Atienza, A. A., Nilsen, W., Allison, S. M., & Mermelstein, R. (2011). Health behavior models in the age of mobile interventions: are our theories up to the task? *Translational behavioral medicine, 1*, 53-71. doi:10.1007/s13142-011-0021-7

Ringle, C. M., Wende, S., & Becker, J.-M. (2015). SmartPLS 3. Bönningstedt: SmartPLS. Retrieved from http://www.smartpls.com/

Robinson, T. N., Patrick, K., Eng, T. R., & Gustafson, D. (1998). An evidence-based approach to interactive health communication: a challenge to medicine in the information age. Science Panel on Interactive Communication and Health. *JAMA, 280*(14), 1264-1269.

Rogers, E. M. (2010). *Diffusion of Innovations* (4th Edition ed.). New York: Free Press.

Sandelowski, M. (1995). Sample size in qualitative research. *Research in nursing & health, 18*(2), 179-183.

Sandelowski, M. (2000). Combining qualitative and quantitative sampling, data collection, and analysis techniques in mixed-method studies. *Research in nursing & health, 23*, 246-255.

Schulman-Green, D., Jaser, S., Martin, F., Alonzo, A., Grey, M., McCorkle, R., . . . Whittemore, R. (2012). Processes of self-management in chronic illness. *J Nurs Scholarsh, 44*(2), 136-144. doi:10.1111/j.1547-5069.2012.01444.x

Schulte, M., Liang, D., Wu, F., Lan, Y. C., Tsay, W., Du, J., . . . Hser, Y. (2016). A Smartphone Application Supporting Recovery from Heroin Addiction: Perspectives of Patients and Providers in China, Taiwan, and the USA. *J Neuroimmune Pharmacol*. doi:10.1007/s11481-016-9653-1

Scott, P. J., & Briggs, J. S. (2009). A Pragmatist Argument for Mixed Methodology in Medical Informatics. *Journal of Mixed Methods Research, 3*, 223-241. doi:10.1177/1558689809334209

Shah, S. G. S., Barnett, J., Kuljis, J., Hone, K., & Kaczmarski, R. (2013). Factors determining patients' intentions to use point-of-care testing medical devices for self-monitoring: the case of international normalized ratio self-testing. *Patient preference and adherence, 7*, 1-14. doi:10.2147/PPA.S38328

Shahriyar, R., Bari, F., Kundu, G., Ahamed, S., & Akbar, M. (2009). Intelligent mobile health monitoring system (IMHMS). *International Journal of Control and Automation, 2*, 13-27. doi:10.1007/978-3-642-11745-9_2

Sicotte, C., Pare, G., Morin, S., Potvin, J., & Moreault, M. P. (2011). Effects of home telemonitoring to support improved care for chronic obstructive pulmonary diseases. *Telemed J E Health, 17*(2), 95-103. doi:10.1089/tmj.2010.0142

Sinuff, T., Cook, D. J., & Giacomini, M. (2007). How qualitative research can contribute to research in the intensive care unit. *Journal of Critical Care, 22*, 104-111. doi:10.1016/j.jcrc.2007.03.001

Smith, A. (2015). US smartphone use in 2015. *Pew Research Center*, 18-29.

Sohanpal, R., Seale, C., & Taylor, S. J. (2012). Learning to manage COPD: a qualitative study of reasons for attending and not attending a COPD-specific self-management programme. *Chron Respir Dis, 9*(3), 163-174. doi:10.1177/1479972312444630

Sohanpal, R., Steed, L., Mars, T., & Taylor, S. J. (2015). Understanding patient participation behaviour in studies of COPD support programmes such as pulmonary rehabilitation and self-management: a qualitative synthesis with application of theory. *NPJ Prim Care Respir Med, 25*, 15054. doi:10.1038/npjpcrm.2015.54

Stearns, S., Bernard, S. L., Fasick, S. B., Schwartz, R., Konard, T. R., Ory, M. G., & Defriese, G. H. (2000). The Economic Implications of Self-Care: The Effect of Lifestyle, Functional Adaptations, and Medical Self-Care Among a National Sample of Medicare Beneficiaries. *American Journal of Public Health, 90*, 1608-1612.

Stoilkova-Hartmann, A., Janssen, D. J., Franssen, F. M., Spruit, M. A., & Wouters, E. F. (2015). Attitudes of healthcare professionals providing pulmonary rehabilitation toward partnership in care. *Heart Lung, 44*(4), 347-352. doi:10.1016/j.hrtlng.2015.05.003

Stone, M. (1974). Cross-validatory choice and assessment of statistical predictions. *Journal of the royal statistical society. Series B (Methodological)*, 111-147.

Straub, D., & Keil, M. (1997). Testing the technology acceptance model across cultures: A three country study. *Information & Management, 33*(1), 1-11.

Szajna, B. (1996). Empirical Evaluation of the Revised Technology Acceptance Model. *Management Science, 42*(1), 85-92. doi:10.1287/mnsc.42.1.85

The World Bank. (2017). Mobile cellular subscriptions (per 100 people). Retrieved from https://data.worldbank.org/indicator/IT.CEL.SETS

Thomas, E., & Magilvy, J. K. (2011). Qualitative rigor or research validity in qualitative research. *J Spec Pediatr Nurs, 16*(2), 151-155. doi:10.1111/j.1744-6155.2011.00283.x

Timmerman, J. G., Tonis, T. M., Dekker-van Weering, M. G., Stuiver, M. M., Wouters, M. W., van Harten, W. H., . . . Vollenbroek-Hutten, M. M. (2016). Co-creation of an ICT-supported cancer rehabilitation application for resected lung cancer survivors: design and evaluation. *BMC Health Serv Res, 16*(1), 155. doi:10.1186/s12913-016-1385-7

tMedica. (2017). tMedica. Retrieved from http://www.tmedica.com/

Tuckett, A. G. (2005). Part II. rigour in qualitative research: complexities and solutions. *Nurse researcher, 13*, 29-42. doi:10.7748/nr2005.07.13.1.29.c5998

Tung, F.-C., Chang, S.-C., & Chou, C.-M. (2008). An extension of trust and TAM model with IDT in the adoption of the electronic logistics information system in HIS in the medical industry. *International Journal of Medical Informatics, 77*, 324-335. doi:10.1016/j.ijmedinf.2007.06.006

Ukena, C., Mahfoud, F., Kindermann, M., Kindermann, I., Bals, R., Voors, A. A., . . . Bohm, M. (2010). The cardiopulmonary continuum systemic inflammation as 'common soil' of heart and lung disease. *Int J Cardiol, 145*(2), 172-176. doi:10.1016/j.ijcard.2010.04.082

UPMC. (2013). Lung Transplant Program at UPMC. Retrieved from http://www.upmc.com/services/transplant/organs/lung/Pages/landing.aspx

Varnfield, M., Karunanithi, M., Lee, C. K., Honeyman, E., Arnold, D., Ding, H., . . . Walters, D. L. (2014). Smartphone-based home care model improved use of cardiac rehabilitation in postmyocardial infarction patients: results from a randomised controlled trial. *Heart, 100*(22), 1770-1779. doi:10.1136/heartjnl-2014-305783

Vathsangam, H., Qiao, S., Berkley, J., Adesanya, A., Sukhatme, G., Grazette, L., & Fong, M. (2015). Smartphone Delivered Cardiac Rehab for Heart Failure Management: A Feasibility Study. *Circulation, 132*(Suppl 3), A12543-A12543.

Venkatesh, V. (2000). Determinants of Perceived Ease of Use : Integrating Control , Intrinsic Motivation , and Emotion into the Technology Acceptance Model. *Information System Research, 11*, 342-365. doi:10.1287/isre.11.4.342.11872

Venkatesh, V., & Bala, H. (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. *Decision Sciences, 39*, 273-315. doi:10.1111/j.1540-5915.2008.00192.x

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science, 46*, 186-204. doi:10.1287/mnsc.46.2.186.11926

Venkatesh, V., & Morris, M. G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. *MIS quarterly*, 115-139.

Venkatesh, V., Morris, M. G., & Ackerman, P. L. (2000). A Longitudinal Field Investigation of Gender Differences in Individual Technology Adoption Decision-Making Processes. *Organizational Behavior and Human Decision Processes, 83*, 33-60. doi:10.1006/obhd.2000.2896

Venkatesh, V., Morris, M. M. G., Davis, G. G. B., & Davis, F. D. F. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS quarterly*, *27*, 425-478. doi:10.2307/30036540

Verwey, R., van der Weegen, S., Spreeuwenberg, M., Tange, H., van der Weijden, T., & de Witte, L. (2014). A pilot study of a tool to stimulate physical activity in patients with COPD or type 2 diabetes in primary care. *Journal of telemedicine and telecare*, *20*, 29-34. doi:10.1177/1357633x13519057

Walsh, I. (2015). Using quantitative data in mixed-design grounded theory studies: an enhanced path to formal grounded theory in information systems. *European Journal of Information Systems*, *24*(5), 531-557. doi:10.1057/ejis.2014.23

White, P. (2000). Doctors and nurses. Let's celebrate the difference between doctors and nurses. *BMJ*, *321*(7262), 698.

Willis, G. B., Smith, T., & Lee, H. J. (2013). Do additional recontacts to increase response rate improve physician survey data quality? *Med Care*, *51*(10), 945-948. doi:10.1097/MLR.0b013e3182a5023d

World Health Organisation. (2015). Noncommunicable diseases. Fact sheet. Retrieved from http://www.who.int/mediacentre/factsheets/fs355/en/

World Health Organization. (2011). *Global status report on noncommunicable diseases 2010*. Geneva, Switzerland: World Health Organization.

World Health Organization. (2014). The top 10 causes of death. Retrieved from http://www.who.int/mediacentre/factsheets/fs310/en/

Wu, J.-H., Wang, S.-C., & Lin, L.-M. (2007). Mobile computing acceptance factors in the healthcare industry: a structural equation model. *International Journal of Medical Informatics, 76*, 66-77. doi:10.1016/j.ijmedinf.2006.06.006

Ye, C. (2008). Users ' Personality and Perceived Ease of Use of Digital Libraries : The Case for Resistance to Change. *59*, 845-851. doi:10.1002/asi

Yi, M., Jackson, J., Park, J., & Probst, J. (2006). Understanding information technology acceptance by individual professionals: Toward an integrative view. *Information & Management, 43*, 350-363. doi:10.1016/j.im.2005.08.006

Zhang, H., Cocosila, M., & Archer, N. (2010). Factors of adoption of mobile information technology by homecare nurses: a technology acceptance model 2 approach. *Computers, informatics, nursing : CIN, 28*, 49-56. doi:10.1097/NCN.0b013e3181c0474a