IMPLEMENTATION LEADERSHIP CHARACTERISTICS OF FIRST-LEVEL LEADERS AND NURSES' USE OF MOBILE HEALTH TECHNOLOGIES

by

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Abstract

Aims: The purpose of this study was to examine the effects of first-level leaders' implementation leadership characteristics on nurses' intention to use and actual use of mHealth in practice while controlling for nurses' individual characteristics, voluntariness, perceived usefulness, and perceived ease of use of mHealth.

Background: The use of mobile technologies in healthcare (mHealth) has increased exponentially since widespread availability of smartphones. Current understanding of nurses' mHealth use focuses on individual-level factors. There is a need to consider broader contextual factors in shaping mHealth use. One group that may influence nurses' mHealth use are first-level leaders, individuals who are responsible for implementing mHealth. Drawing from implementation science and informed by the importance of leadership in nursing, this study examined the impact of implementation leadership characteristics of first-level leaders on nurses' use of mHealth in practice.

Method: A cross-sectional exploratory correlational survey study of registered nurses in Canada (N = 288) was conducted between January and June 2018. Nurses were eligible to participate if they provided direct care in any setting and used employer provided mHealth in practice. Hierarchical multiple regression analyses were conducted for the two outcome variables, intention to use and actual use.

Results: The implementation leadership characteristics of first-level leaders influenced nurses' intention to use and actual use of mHealth, with two moderating effects found. Implementation leadership had a greater influence on the intention to use mHealth among nurses with an RN diploma or Bachelor of Nursing as compared to nurses with a Graduate degree. For participants of older ages, implementation leadership had less of an influence on nurses' actual use of mHealth.

Conclusion: Leaders responsible for the implementation of mHealth need to assess and consider their implementation leadership behaviours as these play a role in influencing nurses' mHealth use. Education level and age of nurses may be important factors to consider as different groups may require varied approaches to optimize nurses' use of mHealth in practice.

Lay Summary

The use of mobile technologies in healthcare (mHealth) has increased exponentially since widespread availability of smartphones. In healthcare, leadership is considered important in supporting the uptake of technologies, including mHealth, by point-of-care nurses. First-level leaders are the individuals directly responsible for implementing mHealth in nursing clinical practice. However, little is known about how the specific behaviours of first-level leaders influence nurses' use of mHealth. This study examined the extent to which specific leadership characteristics of first-level leaders influenced nurses' use of mHealth at the point-of-care. An online survey of 288 Canadian nurses was conducted between January and June 2018. Results showed that the implementation leadership characteristics of first-level leaders influenced nurses' intention to use and actual use of mHealth depending on nurses' level of education and age. The results from this study can provide practical recommendations that can be used to optimize nurses' use of mHealth in practice.

Preface

This dissertation is the original work of the author, Charlene E. Ronquillo. This study was approved by the University of British Columbia Behavioural Research Ethics Board under the project title: "M-Health and Implementation Leadership Evaluation (MOBILE) Nurse Study" (ethics approval number H17-02831).

I, Charlene E. Ronquillo, was responsible for all aspects of this study, including identification and design of the research program, participant recruitment, data collection, data analysis, and initial drafts of all chapters and manuscripts. Dr. Leanne M. Currie provided guidance on all components of this study including initial study design and subsequent refinements, data collection and analyses, and writing of all chapters and related manuscripts. My supervisory committee members Drs. Leanne M. Currie, V. Susan Dahinten, and Victoria Bungay contributed to the development of the research questions, study design, and draft revisions. Dr. V. Susan Dahinten provided crucial guidance and assistance with data analysis and interpretation of results. Drs. Victoria Bungay and V. Susan Dahinten provided important guidance on aspects of leadership considered in this research. All committee members read and approved the contents of this dissertation.

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Research is never a solitary endeavour and the work conducted for this dissertation was no exception, despite bearing only my name in this document. This dissertation would not have been possible without the participation of nurses across Canada who took the time to participate in this study and share their experiences.

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Dedication

This dissertation is dedicated to all the minority and marginalized persons pursuing your PhDs.

Your very presence in this space is an act of rebellion, shifting the power structures of academia.

I see you. I stand with you. We will not be so invisible, soon.

Chapter 1: Introduction

Nurse leaders are navigating an increasingly complex healthcare system (Stilgenbauer & Fitzpatrick, 2019) that involves widespread use of technologies (Collins et al., 2017; Oakes et al., 2015) including mobile health (mHealth) (Samples et al., 2014). Broadly, mHealth refers to the use of mobile computing and information-communication technologies as a tool to support healthcare systems, health service delivery, and/or the achievement of specific health objectives (World Health Organization, 2011). An often touted unique feature of mHealth is the transformative potential to improve health (World Health Organization, 2011) driven by its key characteristics of mobility, portability, and ever increasing ubiquity (Cinnamon & Ronquillo, 2018; Groupe Spéciale Mobile Association, 2019). Technologies associated with mHealth include personal digital assistants, mobile phones (basic and smart phones), tablet computers, wearable devices, and mobile sensing technologies (Olla & Shimskey, 2015; World Health Organization, 2011). There is particular interest to leverage mobility and portability within nursing, the largest professional group in healthcare worldwide (World Health Organization, 2017) and where there are high rates of smartphone ownership (>90%) (Mobasheri et al., 2015; Wicklund, 2015).

There are growing efforts to better understand how mHealth can be best implemented and used to support nurses' work; the use of mHealth by this cadre of health professionals has potential for transformative impacts on optimizing healthcare delivery and improving patient and population outcomes. However, there are limitations in the current approaches to understanding the nature of nurses' mHealth use and limited insight into the factors that may be most crucial in ensuring the successful implementation of mHealth that will lead to nurses' use of these technologies as part of their clinical practice. These limitations relate to the use of dominant technology acceptance models as tools to understand technology use, which are limited in the ability to consider broader contextual factors that influence nurses' mHealth use. Literature from the field of implementation science highlights the importance of considering contextual and structural factors in understanding the implementation success (and subsequent use) when introducing new innovations (Damschroder et al., 2015; Greenhalgh & Abimbola, 2019). In addition, current approaches taken to understand the factors that influence nurses' mHealth use have yet to consider the unique contextual factors of nursing practice, and in particular, the significance of leadership in influencing nursing practice environment (Laschinger et al., 2009).

The role of leadership in nursing has been investigated from many perspectives. Research has been conducted to examine the impacts of leadership development efforts (MacPhee et al., 2014), and leadership competencies required of nurse leaders in specialized areas (e.g., nursing informatics, implementation) (Collins et al., 2017; Ingebrigtsen et al., 2014). Moreover, links have been found between outcomes for both nurses and patients and leadership styles in nursing (Giltinane, 2013; Mills & McKimm, 2016). Furthermore, the importance of leadership in nursing is supported by position statements both nationally (Granger et al., 2018; Kilty, 2005; Registered Nurses Association of Ontario, 2013) and internationally (Buckner et al., 2014; Cabral et al., 2019; International Council of Nurses, 2019). The Canadian Nurses Association's (CNA) position statement on leadership in nursing emphasizes the importance of nurses' leadership development at all levels (Canadian Nurses Association, 2009). Best practice guidelines by the Registered Nurses Association of Ontario more specifically identify transformational leadership practices as a key recommendation to create and sustain healthy workplace environments (Registered Nurses Association of Ontario, 2013).

The overarching aim of this study was to investigate the role of leadership and characteristics of leaders as a contextual factor that can influence mHealth use among Canadian nurses. A commonly used technology acceptance model formed the "base" for the conceptual model which incorporates the view of leadership from nursing and implementation science (see Chapter 2 for a detailed discussion). As the study specifically investigates the leadership characteristics of first-level leaders who are directly responsible for implementing mHealth in nursing clinical practice, the results from this study can provide practical recommendations that can be used to optimize nurses' use of mHealth in practice.

1.1 What is mHealth?

In order to understand the relevance and potential of mHealth use in nursing, an understanding of mHealth as a broader concept is warranted and presented in this section. A taxonomy of mHealth was developed by Olla and Shimskey (2015) in an attempt to bring some structure to this broad field, informed by a review and qualitative coding of mHealth publications. Eight categories of mHealth use in healthcare were identified. These include mHealth applications for both patient and healthcare professionals. While this study did not measure the specific uses of mHealth, many of the uses described by Olla and Shimskey (2015) can involve nursing practice such as, point of care diagnostics, education and reference, efficiency and productivity, patient monitoring, compliance, and behaviour modification. As such, mHealth was broadly conceptualized in this study in order to capture the breadth of use of various types and functions of technologies.

Table 1.1 Taxonomy of mHealth uses by Olla and Shimskey (2015)

Uses of mHealth for healthcare	Examples
Point of care diagnostics - medical testing at or near the patient	Blood glucose testing
Wellness - general health and wellness promotion not specific to a disease process	Wearable activity trackers
Education and reference - health education resources	Access to clinical references or guidelines via a specialized mobile app
Efficiency and productivity - supporting healthcare professionals to accomplish specific tasks	Charting on mobile devices
Patient monitoring - remote monitoring of patients	Home monitoring to support chronic disease management
Compliance - supporting adherence to a medical or healthcare plan	Interactive medication reminders
Behaviour modification - delivering behaviour modification communication and supporting behaviour change	Text messaging to support smoking cessation
Environmental monitoring - providing information about environmental factors that impact community health	Detecting air allergen levels or UV index via mobile devices

1.2 Nurses' mHealth Use in Canada

Nurses are the single largest group of healthcare professionals in Canada (Canadian Institute for Health Information, 2017) and thus comprise an important group of end users of mHealth. Currently, there is limited understanding of nurses' mHealth use in Canada; national surveys of Canadian nurses' use of digital technologies found that nurses' use of mobile devices in practice is limited (Canada Health Infoway & Canadian Nurses Association, 2014; Canada Health Infoway et al., 2017). The 2014 and 2017 surveys asked whether nurses accessed various electronic functions in clinical practice via workplace computer/laptop or handheld mobile device. Sixteen and 21 electronic functions were listed in the 2014 and 2017 surveys, respectively (e.g., electronic access to provincial/territorial patient electronic health records systems) (Canada Health Infoway & Canadian Nurses Association, 2014; Canada Health Infoway et al., 2017). In 2014 and 2017 respectively, approximately 3% and 7% of respondents had used mobile devices to access these functions, with the largest group accessing electronic clinical decision support tools (Canada Health Infoway & Canadian Nurses Association, 2014; Canada Health Infoway et al., 2017). Exploratory work has found the use of mHealth in nursing can enhance communication between patients, nurses, and other healthcare providers (Anglada-Martinez et al., 2015; Farrell, 2016; Hamine et al., 2015), support nurses to better incorporate patient preferences in nursing care (Lindquist et al., 2008), promote nurse-patient relationships (Chiang & Wang, 2016), and support adherence to clinical guidelines (Mickan et al., 2013). A critical pre-requisite to achieving these potential benefits is first ensuring the successful implementation and use of mHealth by nurses.

1.3 The Importance of Leadership in Implementation of mHealth

Leadership is a fundamental aspect of the nursing profession (Canadian Nurses Association, 2009; Fitzgerald et al., 2017). Just as leadership is a key factor in shaping the implementation and use of innovations and evidence-based practice (Aarons, Ehrhart, & Farahnak, 2014; Reichenpfader et al., 2015; Sandström et al., 2011), leadership is also instrumental in the implementation and subsequent use of mHealth and other health information technologies (HIT) by nurses and other healthcare providers (Gagnon et al., 2012; Gagnon et al., 2016; Ingebrigtsen et al., 2014; Lyles et al., 2016). As mHealth is deployed, understanding the process related to its design, development, and implementation in the context of nursing is important for leaders who are charged with mHealth implementation. The characteristics and behaviours of those in leadership roles are known to play an integral role in the implementation of practice changes in nursing (Aarons, Ehrhart, Farahnak, et al., 2014; Damschroder et al., 2015). In a systematic review of the role of leadership in the implementation of research utilization (i.e., evidence-based practice) (n=17 studies), researchers found that both direct and indirect supportive behaviours of leaders played a role as a modifier, or an intermediate factor, for implementation success (Reichenpfader et al., 2015). Researchers have also found that stronger implementation leadership behaviours increase the use of research in practice (Aarons, Ehrhart, Farahnak, et al., 2014).

In the nursing literature, relationships have been found between various leadership styles and outcomes for both nurses and patients (Giltinane, 2013; Mills & McKimm, 2016). The impacts of leadership behaviours on nurses and their work environment can, in turn, shape nurses' attitudes and behaviours towards new innovations in practice. For example, transformational leadership – operationalized in many studies as comprised of behaviours such as clear communication of organizational values and roles, and demonstrating supportive or facilitative behaviours (Reichenpfader et al., 2015) – is suggested to facilitate improved patient outcomes (Higgins, 2015; Wong et al., 2013), improve nurses' perceptions of their psychosocial work environments (Malloy & Penprase, 2010), and influence nurses' behaviours towards the use of new innovations introduced in their organizations (Weng et al., 2015). The studies discussed in this section highlight that leaders' specific behaviours and characteristics may influence nursing outcomes such as research use, perceptions of support, work environments, and workplace climate, among other outcomes.

Little is known about what it takes to effectively embed mHealth in health systems. Much of the literature on mHealth implementation has focused on its use in low-resource settings by non-professional health service providers. Thus, mHealth implementation in the context of nursing remains largely unexplored. Technology acceptance models, as the primary lens to understand technology use behaviours, have dominated the study of mHealth in the context of nursing practice. While this approach has provided important insight into key factors that are thought to consistently influence the use of mHealth, there is a need for better consideration of nursing-specific contexts beyond technology acceptance models alone. In particular, the role that nursing leadership plays in the use of mHealth is unknown, despite its recognized importance in nursing practice overall.

1.4 Problem Statement

Important factors identified in studies that have examined the use of technologies include individual demographic characteristics and individual characteristics related to technology. The role of leadership is frequently identified as an important factor in influencing the successful implementation of mHealth. However, there is an overall underdevelopment of the concept of leadership in relation to implementation of mHealth. There is a need to better understand the nature of the relationships between leadership characteristics and nurses' individual characteristics in order to inform how mHealth implementation in nursing can support nurses' use of these technologies.

1.5 Purpose

The purpose of this study was to examine the effects of implementation leadership characteristics, nurse demographic and technology characteristics, voluntariness, perceived usefulness, and perceived ease of use, on nurses' use of mHealth in direct patient care.

1.6 Research Questions

The following research questions were examined:

- **Research Question 1:** What is the relationship between (a) implementation leadership characteristics and (b) nurses' intention to use and (c) actual use of mHealth, after controlling for (d) perceived usefulness and perceived ease of use, (e) nurses' previous experience with mobile technology and voluntariness of use, and (f) nurses' demographic characteristics?
- **Research Question 2:** Do nurses' (a) demographic characteristics moderate the relationship between (b) implementation leadership characteristics and (c) nurses' intention to use and (d) actual use of mHealth?
- **Research Question 3:** Do nurses' (a) voluntariness of use moderate the relationship between (b) implementation leadership characteristics and (c) nurses' intention to use and (d) actual use of mHealth?

1.7 Summary

This dissertation is comprised of the following chapters: Chapter 1 provides an overview of the background and problem, purpose, research questions, and the outline of the dissertation document. In Chapter 2, a synthesis of the relevant research about leadership in nursing and health information technology (HIT) that informed the development of this study is described. Chapter 2 concludes with a conceptual model that informed the design and methods of this study. In Chapter 3, a detailed description of the study design, sampling strategy, data collection procedures, operationalization of study variables, analytic methods, and ethical considerations are described. In Chapter 4, the key findings resulting from the main analyses are reported. In Chapter 5, the study findings are discussed relative to other current evidence and a concluding discussion of the study strengths and limitations, theoretical implications, practical implications, and potential future research directions are presented.

Chapter 2: Literature Review

In this chapter, the review of the literature relevant to leadership factors, technology factors and nurses' individual-level factors that influence nurses' intention to use and actual use of mHealth are presented and discussed. To help organize this discussion, I present the review of the current state of knowledge organized into five primary categories: 1) Leadership in relation to nurses' use of mHealth; 2) Leadership in relation to nurses' use of other health information technologies (HIT); 3) Leadership in nursing and implementation leadership characteristics; 4) Technology acceptance models as a dominant lens for technology use; and 5) Technology and individual characteristics related to nurses' use of mHealth, HIT and research. Following the main discussion of the literature, a conceptual model that was informed by this literature review and used to guide the design and methods used in this study is described. I conclude this chapter with a summary of the strengths and limitations of this literature and the relevance for my dissertation study.

2.1 Search Strategy

The Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE®, and Google Scholar databases were searched for publications between 2007 and 2017, prior to the launch of this study's data collection. Search terms included keyword and subject headings for the following concepts and their variants: "nurses," "mHealth," "health technology," "leadership," and "implementation." All possible combinations of search terms and their variations that include each of the abovementioned concepts were used. The search was limited to scholarly research and review articles published in peer-reviewed journals, English publications with available full text, and empirical studies. The literature on the role of leadership in influencing the use of mHealth by nurses is described in the first sub-section.

2.2 Leadership in the Implementation and Use of mHealth

The studies described in this section include those that predominantly examined the influence of leadership on mHealth use in healthcare. A consistent trend across the majority of the studies was the indirect and implicit ways that leadership was discussed, and no studies could be identified that examined the nature of leadership (i.e., characteristics of leaders, leadership behaviours, supports provided by leaders) in relation to nurses' use of mHealth. One study of relevance is a systematic review of research concerned with the individual, organizational, and broader environmental barriers and facilitators to mHealth use by health professionals (33 papers; 2 publications related to the same study). In this review by Gagnon and colleagues (2016), the authors examined characteristics of the mHealth technologies (e.g., design and technical aspects of the technology, perceptions of usefulness and ease of use of the technology, compatibility of technologies with existing work processes, reliability and dependability of the technology, interoperability, privacy, security, and legal considerations, etc.), characteristics of the individuals using the technology (e.g., knowledge, attitudes, socio-demographic characteristics), characteristics related to the human environment (e.g., patients' and colleagues' attitudes and receptiveness to the technology, impacts of technology use on clinician-patient interactions, etc.), and characteristics related to the organizational environment (e.g., workloads, work flexibility, communication patterns and relationships among colleagues, support resources and training provision, readiness, management support to implement mHealth, healthcare policies and socio-political context, etc.). "Management support" was identified as an element of the organizational environment that can facilitate mHealth use, although no information was offered to distinguish what level of management was involved, what “good support” might look like, and what types of leadership behaviours were important.

Similar conclusions were drawn in a community-based participatory action research study by Petrucka and colleagues (2013) which examined the use of mHealth in five healthcare sites in the Caribbean (*n*=254 nurses and *n*=23 nursing students). The authors employed quantitative and qualitative approaches over a period of four years to examine nurses’ experiences and ways of promoting the use of an introduced mHealth tool. Five lessons learned in developing and implementing mHealth in this public health context were reported: 1) Build mHealth awareness and availability first; 2) Address the contextual features of the setting, place and people in design and implementation; 3) Embed evidence/content to catalyze innovation use; 4) Coordinate for achievement at different levels of health service delivery; and 5) Attend to knowns and be attendant to unknowns (Petrucka et al., 2013). Similar to conclusions drawn by Gagnon et al. (2016), the authors do not make explicit links between these five lessons learned with the role of leadership, although arguably, these links can be made. For example, leaders can play key roles in building mHealth awareness and availability within local contexts, ensure that relevant knowledge are embedded in the technology to support nurses’ work, lead the coordination of implementation efforts, and have important insight into potential knowns and unknowns that can shape the successful implementation and subsequent use of mHealth.

One Danish study provided more detailed insight into leadership characteristics and practices as influencing nurses’ mHealth use (Nielsen & Mathiassen, 2013). This longitudinal case study spanned 10 years (1998-2008) and included surveys, written materials, and interviews with managers, nurses, and care workers in three large scale implementations of mHealth in the Danish home care sector. Findings illustrated that variation in leaders' understandings and valuing of mHealth ultimately influenced how mHealth was implemented and subsequently used by nurses. By the end of the study (i.e., after 10 years), mHealth was used by most home care agencies included in the study and there was support at the managerial level for mHealth implementation. However, the process of implementing mHealth across sites varied and resulted in different experiences, ways of using, resistance to, and valuing of mHealth. Results from this study suggests that although managerial support was present at all sites, there were likely differences in the practices which translated to differences in how mHealth implementation was enacted in practice. Given the variations in the ways that mHealth were implemented in different sites and the approach to implementation taken up at each site was not described, the question remains as to what influenced the behaviours of leaders related to the implementation of mHealth.

The studies described in this section illustrate that leadership has been highlighted as an important influence for mHealth implementation and use, although a detailed understanding of leadership is lacking. Notwithstanding these limitations, these case studies provide some evidence that leadership has a role in influencing the adoption and long-term use of mHealth in nursing practice and a better understanding of the complex process of mHealth use that considers leadership as an aspect of contextual variability.

2.3 Leadership in the Implementation and Use of HIT

Because mHealth is subsumed to some extent within HIT, I reviewed additional literature concerned with leadership and technology use in nursing more broadly. A study by Walker and Clendon (2016) examined nurse leaders' perspectives and attitudes toward the use of eHealth, which the authors defined as "an overarching term describing health informatics, telemedicine services and information delivered or enhanced through electronic connectivity, the Internet and all related technologies" (Walker & Clendon, 2016, p. 443). Results from focus groups with senior nurse leaders, nurse managers, and community nurses (n=36) identified several barriers to eHealth use, including inadequate access to appropriate hardware and other required resources (e.g., connectivity, standardization between systems, training). These findings echo similar patterns in the previous section where the role of leadership is not explicitly addressed but rather implicitly assumed from the identified barriers and facilitators. For example, the barrier related to inadequate access to appropriate hardware and infrastructure resources to support eHealth usage are potentially target areas where nurse leaders can provide support by facilitating adequate access to eHealth, ensuring appropriateness of hardware for use by clinicians, and advocating for staff nurses' involvement throughout the development, deployment, and implementation of eHealth. Indeed, these leadership-driven activities are supported by the authors' finding that particular employers in their study saw great benefit from a heavy investment in ensuring end-user involvement throughout all stages of development, training, and implementation (Walker & Clendon, 2016).

Leadership was identified as an important facilitator of HIT use in Gagnon et al.'s (2012) systematic review, echoing results of their later systematic review on mHealth use by healthcare professionals discussed in the previous section. Two of the studies included in the review point to the influential role of interdisciplinary teams that included nurses (Gagnon et al., 2012). Again, no explicit links were made to the possible roles and behaviours of leaders that influence HIT use, although a higher level discussion of leadership to facilitate HIT use was provided in the recommendations. These recommendations suggest that: 1) Leaders should ensure the active involvement of end-users throughout the implementation process; 2) Leaders should identify and support key influencers and champions to encourage the use of HIT and lead the implementation of projects; and 3) Leaders should ensure adequate training for end-users (Gagnon et al., 2012). Similar to previous studies discussed, specific behaviours, characteristics, roles, and levels of leaders must be alluded to from the aforementioned recommendations, given that the authors do not discuss these links explicitly.

Other systematic reviews that have examined factors associated with use of HIT similarly emphasize the importance of leadership as a high-level concept but offer limited detail. A systematic review that examined the factors related to the use of electronic health records in long-term care facilities identified the need for "strong leadership" to ensure the alignment of electronic health record implementation with the strategic planning within institutions (Kruse et al., 2015); what "strong leadership" entailed was not described further. Another systematic review that investigated what is required of nurse leaders to foster capacity for the safe use of HIT points to the pivotal role of nurse leaders (Poe, 2011). The authors conclude with a call for nurse leaders to build capacity within nursing staff to facilitate the use of HIT and ensure that its use in nursing is well-supported and meaningful, although practical guidance in achieving this aim was not offered (Poe, 2011). This is in line with other reviews (Boonstra et al., 2014; Randazzo & Brown, 2016; Ross et al., 2016; Yesenofski et al., 2015) and several studies (Birken et al., 2016; Birken et al., 2012; Birken et al., 2015; de Souza et al., 2017; Kerrissey et al., 2017; Lalley, 2014; Varsi et al., 2015; Yen et al., 2017), where potential facilitative leadership characteristics and behaviours to promote HIT use among nurses are implicit in authors' recommendations. As such, looking to barriers and facilitators identified in these studies can provide a likely starting point for identifying and making explicit the specific implementation leadership characteristics and behaviours that can facilitate nurses' use of HIT.

Moving beyond implicit suggestions for the role of leaders, a number of studies were identified that examined leadership characteristics and behaviours more specifically in the context of HIT implementation and use. One study is a systematic review by Ingebrigtsen and colleagues (2014) that examined attributes of clinical leaders – defined in their study as "those responsible for leadership within an organisation…that delivers care" – and their association with HIT use (p. 398). In their review, attributes of clinical leaders who had technical informatics skills and prior experience with HIT project management were found to be associated with HIT use among doctors and nurses (Ingebrigtsen et al., 2014). The authors highlight the importance of proactive leadership behaviours, vision and long-term commitment, and perseverance, among important leadership behaviours that can facilitate HIT implementation (Ingebrigtsen et al., 2014).

Perhaps the most substantial contribution to understanding which aspects of leadership are most important in facilitating HIT use among healthcare professionals is the comprehensive review of the literature conducted by Sligo and colleagues (2017). This review of 367 publications examined large-scale planning, implementation, and evaluation of health information systems (a type of HIT). The authors concluded that "strong 'top-down' leadership guidance and support is required, highlighting that a crucial aspect of this leadership is effective communication across managerial, information technology, administrative, and clinical boundaries" (Sligo et al., 2017, p. 93). Indeed, managers considered a lack of senior leaders and "project champions" to be the most substantial risk to successful implementation (Sligo et al., 2017), also reflected elsewhere (Paré et al., 2011). Sligo et al. (2017) identified several aspects of leadership found to be especially important in implementation, including leaders having a clear vision and plan for implementation, being aware of the evidence for effectiveness of the system to be deployed, having insight into unanticipated consequences of implementing the system, having awareness of the implementation as being lengthy, disruptive, and expensive, ensuring adequate resources for the implementation process, having the knowledge and ability to manoeuvre the complexities of health systems and its inter-related parts, facilitating communication within complex health systems, and awareness of human factors and the role they play in implementation. Furthermore, Sligo and colleagues (2017) found that different levels of leadership (e.g., executive level versus local level) were associated with different responsibilities, influence, and interactions with point-of-care staff, who, in turn, intended to use the systems in different ways (Sligo et al., 2017). It is therefore suggested that the most suitable leadership behaviours to achieve intended implementation goals will differ according to the level of leadership involved (Sligo et al., 2017).

2.4 Leadership in Nursing and Implementation Leadership Characteristics

In this section, I begin by presenting the ways leadership has been examined in nursing and the relevance of the concept of leadership in the nursing profession, broadly. In the sections that follow, I present a discussion of leadership in the context of implementation science theories and frameworks. I conclude with a discussion of the concept of implementation leadership characteristics and how these may influence nurses' intention to use and actual use of mHealth to support direct patient care.

Leadership comprises a substantial and important body of work in nursing and has been examined from numerous perspectives. For example, there is much research into influences on and impacts of leadership, including the impacts of leadership development efforts on nurse leaders (MacPhee et al., 2014), leadership competencies that are required to support nurses and other leaders in specific topic areas (e.g., nursing informatics, implementation) (Collins et al., 2017; Ingebrigtsen et al., 2014), and associations between leadership styles outcomes for both nurses and patients (Giltinane, 2013; Mills & McKimm, 2016). Strong leadership has been associated with higher nurses' job satisfaction, stronger organizational commitment (Cummings et al., 2010; MacPhee et al., 2012), lower patient mortality, and higher patient satisfaction (Wong et al., 2013), highlighting the role of leadership in nursing in shaping nursing and patient outcomes. Furthermore, the association between relational leadership styles (transformational and authentic leadership styles)[1] and improved nursing workforce and work environment outcomes (e.g., nurse job satisfaction) are re-emphasized in recent systematic reviews (Cummings et al., 2018; McCay et al., 2018), attesting to the important role of leadership in nursing practice.

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[1] Relational leadership styles are described as being focused on people and relationships. Transformational and authentic leadership styles fall under this broad heading. Transformational leadership styles focus on maximizing the potential of followers through encouragement and intellectual stimulation. Authentic leadership styles focus on valuing and demonstrating transparency and congruence between actions and expressed beliefs (Cummings et al., 2018).

In implementation science, leadership is recognized to play a key role in the success of implementing any type of innovation or change. The rapidly developing field of implementation science is defined as "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice," which includes the study of what influences the behaviours of healthcare professionals and organizations (Eccles & Mittman, 2006, p. 1). The relevance of leadership is evidenced by the inclusion of leadership as a key construct or variable in numerous implementation science theories, models and frameworks (Nilsen, 2015). For example, the role of leadership is identified within two domains of the Consolidated Framework for Implementation Research (CFIR): the inner setting (in the variables learning climate and leadership engagement) and process of implementation (in the variables opinion leaders and formally appointed internal implementation leaders) (Damschroder et al., 2009; Kirk et al., 2015; Nilsen, 2015). Beyond CFIR, other implementation science frameworks include leadership as an important component where leadership is named explicitly (e.g., in the Promoting Action on Research Implementation in Health Services (PARIHS) framework and its more recent iterations (i-PARIHS) (Harvey & Kitson, 2016; Helfrich et al., 2010)) or where the role of leadership is more implicit (e.g., captured as part of organizational characteristics) (Nilsen, 2015).

There is developing work that aims to provide a more nuanced understanding of the role of leadership in influencing the success of implementation outcomes, more specifically, the role of specific characteristics and skills of leaders. Aarons et al. (2014), who have developed much of this work in the context of implementing evidence-based practice, describe the concept of *implementation leadership.* Implementation leadership refers to the notion that "leaders can enact specific implementation leadership and transformational leadership strategies to enhance structures, processes, and activities that promote outer system and inner organizational climates conducive to [evidence-based practice] implementation" (p. 5). With the aim of developing pragmatic ways of understanding implementation leadership, Aarons et al. (2014) developed the Implementation Leadership Scale (ILS), a tool which corresponds with and measures dimensions of implementation leadership characteristics as conceptualized by the authors. The concept of implementation leadership and corresponding dimensions of the ILS are comprised of: 1) Proactive leadership - leaders establish standards, develop plans, and remove obstacles to implementation; 2) Knowledgeable leadership - leader understands and is able to articulate knowledge of evidence-based practice; 3) Supportive leadership - leader supports others' efforts to learn and utilize evidence-based practice; and 4) Perseverant leadership - leader supports evidence-based practice implementation in a consistent and deliberate way (Aarons, Ehrhart, & Farahnak, 2014, p. 4). Looking to the multidimensional concept of implementation leadership presents an opportunity to focus on behaviours of leaders that are specifically thought to influence implementation success and may provide insight into what leaders do to optimize the success of mHealth implementation.

Implementation leadership is specifically concerned with the leadership behaviours of local-level leaders or "first-level" leaders as they are well-positioned to facilitated the implementation of innovations (Schein, 2010) and deemed especially critical to organizational effectiveness (Priestland & Hanig, 2005). First-level leaders are described as those who supervise individuals providing direct services (Schein, 2010). In the case of nursing, first-level leaders would be individuals who oversee nurses that provide direct patient care (e.g., educators, charge nurses, managers), thus having influence at the local unit or department level. Echoing earlier discussions, there is support for the importance of the role of leaders in implementation with the reference to leadership conceptualized in studies in different ways. There have been a number of studies conducted focused on first-level leadership in healthcare that support the important of role of this level of leadership (Aarons et al., 2011; Edmondson, 2003; Ingebrigtsen et al., 2014; Nembhard & Edmondson, 2006; Powell et al., 2012; Sandström et al., 2011; Wensing et al., 2009). In nursing, first-level leadership is more commonly referred to as "unit-level" leadership. Nevertheless, this literature demonstrates similar support for the importance of individuals in these unit-level (i.e., first-level) leadership roles in influencing the implementation and subsequent uptake of practice changes and other innovations among nurses (Robinson et al., 2016; Ryan et al., 2015; Stavor et al., 2017). As first-level leaders are often responsible for the day to day responsibilities related to supporting many new implementations in nursing, it is reasonable to suggest that first-level leaders are likely to play central roles in supporting nurses' use of mHealth that are implemented in their practice setting. In summary, research concerning first-level leadership is lacking, a situation influenced by dominant approaches to studying mHealth use in nursing, as discussed in the next section.

2.5 Technology Acceptance Models as a Dominant Lens for Technology Use in Nursing

Technology acceptance models have been a dominant lens to understand the use of mHealth and HIT in nursing. The persistence in using these models suggest that they represent important foundations in understanding individuals' use of technologies. Several of the key components of technology acceptance models were used as a "base" for the conceptual framework for this study, thus, a brief overview of technology acceptance models is presented here. There has been substantial evolution in the ways that technology acceptance models have been taken up and used, namely, through the revision and addition of various components in these models. In this section, the development of commonly used technology acceptance models will be discussed and the limitations in understanding technology use through these models will be presented. Ways that technology use has typically been measured will be discussed, along with common critiques. The section will conclude by making the case for the need to move beyond common components and measures commonly used in technology acceptance models.

2.5.1 The Evolution of Technology Acceptance Models

Among a number of technology acceptance models that are used, many researchers have used the Technology Acceptance Model (TAM) (Figure 2.1) (Davis, 1989; Davis et al., 1989), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Figure 2.2) (Venkatesh et al., 2003), and more recently the Technology Acceptance Model 3 (TAM3) (Figure 2.3) (Venkatesh & Bala, 2008) to explain and understand nurses' technology use behaviours. The core premise of TAM is that an individual's *intention to use* and subsequent *actual use* of technologies relies largely on the individual's attitudes toward technologies. The initial TAM adapted Ajzen and Fishbein's (1991) social-psychological-behavioural Theory of Reasoned Action to a technological context and drew from studies that highlighted *perceived usefulness* and *perceived ease of use* as important predictors of individuals' intention to use technology (Chuttur, 2009; Davis, 1989; Davis et al., 1989; Holden & Karsh, 2010). Briefly, intention to use was drawn directly from the Theory of Reasoned Action and is defined as "a person's subjective probability that he will perform some behavior," whereas in the original TAM model 'actual use' was measured via self-reported use of a specific technology using a Likert scale that ranged from "Don't use at all," to "Use several times each day" (Davis, 1989; Davis et al., 1989).

The model defines perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989; Davis et al., 1989) and perceived ease of use as "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989; Davis et al., 1989). Several years later Venkatesh and Davis extended TAM and incorporated other theories of technology use in the UTAUT (Venkatesh et al., 2003). The UTAUT made external variables more explicit and suggested mediation and moderation effects. TAM3 was proposed in 2008 in an attempt to better capture external and contextual factors, such as subjective norms[2] (also known as social influence), that influence an individual's perception of usefulness and perception of ease of use as well as other direct effects on an individual's use of technologies. TAM3 has largely been used in the context of e-commerce, with some emerging work in healthcare (Kim & Park, 2012).

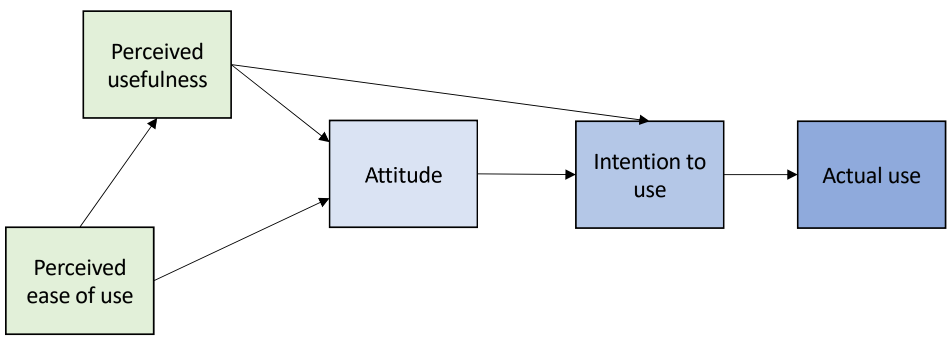

Figure 2.1: Technology Acceptance Model (TAM) (adapted from Davis, 1989)

[2] Subjective norms (in TAM3) or social influence (in UTAUT) refers to belief of an individual that people who are important to him/her thinks that they should perform the behaviour in question (Venkatesh & Davis, 2000).

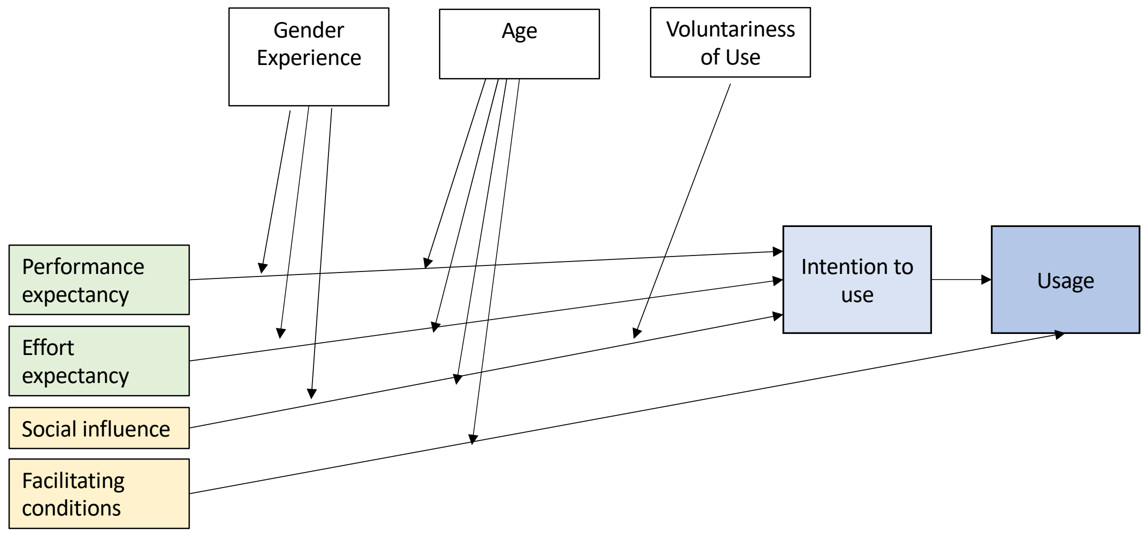

Figure 2.2: Unified Theory of Acceptance and Use of Technology (UTAUT) (adapted from Venkatesh et al., 2003)

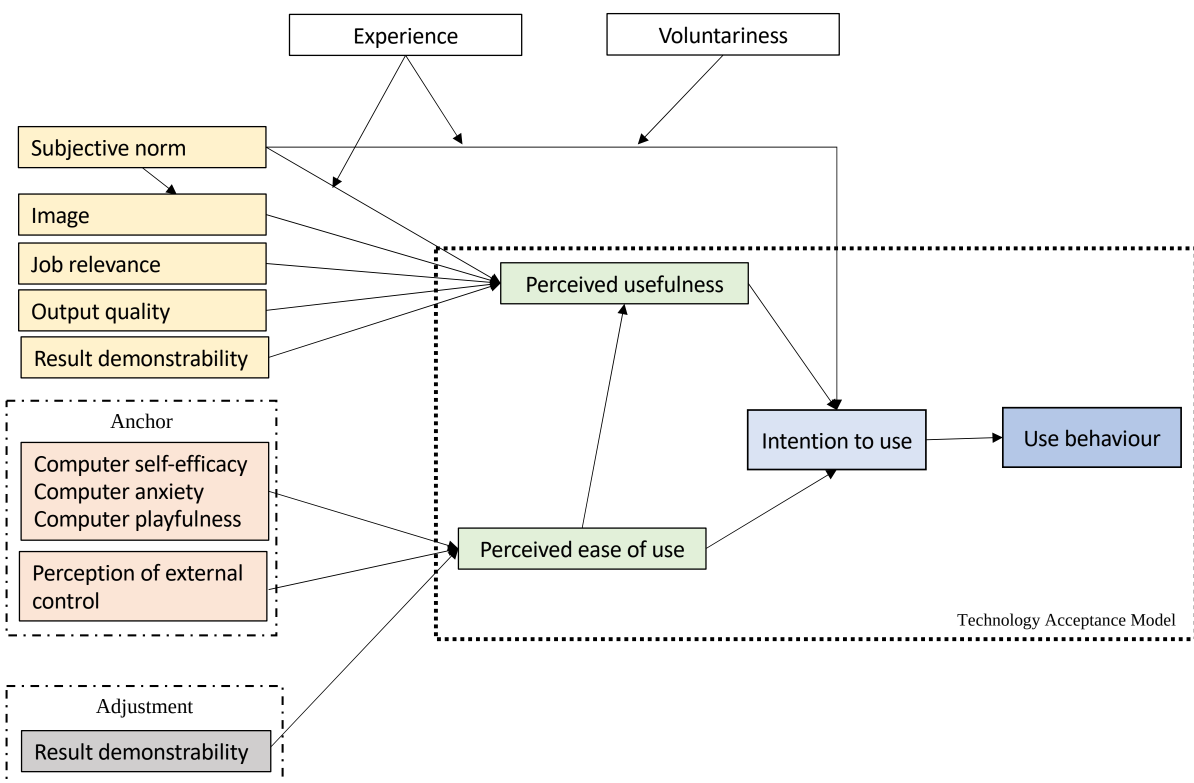

Figure 2.3: Technology Acceptance Model 3 (adapted from Venkatesh & Bala, 2008)

These models have been used in hundreds of studies (Ma & Liu, 2004; Turner et al., 2010; Yousafzai et al., 2007), including over 100 studies in healthcare (Holden & Karsh, 2010) (Khong et al., 2015) with at least 20 focusing specifically on nurses (Strudwick, 2015). Over time, the concepts of perceived usefulness and perceived ease of use have persisted in the models and are captured explicitly within TAM and TAM3 but are subsumed within the concepts of performance expectancy and effort expectancy in UTAUT. A notable change between the models is that previous experience with technology and voluntariness of use were not included in TAM, but are explicit in both UTAUT and TAM3, suggesting that these concepts are persistently relevant. Meanwhile, the role of individual demographic characteristics (gender, age) are included in UTAUT but not in TAM3, suggesting possible inconsistency as to their influence on the use of technologies. In addition to these changes in the models, many researchers have adapted and tested the models in many different contexts which makes it challenging to explicitly interpret the findings. Despite these challenges, the widespread use of technology acceptance models provides a solid foundation for using it in studies of technology use in nursing.

2.5.2 Measurement of Technology Use

Many studies that have examined technology use by nurses and other healthcare providers have focused on understanding what influences the adoption and of technology. In the reviews by Gagnon et al. (2012; 2016), which examined what influenced the use of HIT (including mHealth) and mHealth exclusively, the terms used to describe use of the technologies included “healthcare professionals’ ICT adoption” and “healthcare provider utilization of m-health in their work.” Thus, the terms “adoption,” “use,” and “utilization” are used interchangeably and as overarching terms to describe technology use. In the review by Strudwick (2015) four of the 20 studies focused on mHealth and all studies measured "intention to use" and not actual use of mHealth. In a more recent study by Zhou et al. (2016), it was unclear how they measured mHealth use other than to indicate that the most important factors that impacted use were facilitating conditions, perceived usefulness, and social influence.

There have been in-depth discussions of the issues with current ways that technology use is conceptualized and measured (see (DeLone & McLean, 2016) for a detailed discussion). Criticisms of TAM (which has "intention to use" as the measure of technology use) question how well *intention* to use predicts *actual* use behaviours (Turner et al., 2010). The evidence is mixed. Some have found fairly consistent relationships (Legris et al., 2003; Turner et al., 2010; Venkatesh & Bala, 2008). Meanwhile, other studies where objective measures of actual use behaviours were used have found the relationship between intention and behaviours to be non-significant (Dishaw & Strong, 1999; El Halabieh et al., 2017; Taylor & Todd, 1995) and suggest that the discrepancy may be attributed to inaccuracies in respondents' self-reported use behaviours (Wu et al., 2012). Part of the challenge has been that many studies measure only intention to use and draw conclusions related to technology use, often without measuring other actual use behaviours (Limayem et al., 2007; Wu et al., 2012); the predictive link between intention to use and actual use are assumed. Similar mixed findings can be found outside of the technology acceptance literature, with some support for the predictable relationships between intention and actual behaviours of clinicians (Eccles et al., 2006) and others suggesting a discrepancy between intentions and behaviours (Hung et al., 2016; Jenner et al., 2006). Despite the uncertainty in the causal effect of intention to use on actual use behaviours, intention to use remains among the most common measures of technology use, alongside increasing efforts to include additional measures of use.

In an attempt to understand actual use in the context of nursing practice, Maillet et al. (2014) incorporated Doll and Torkzadeh's (1998) multidimensional measure of *actual use* into UTAUT to measure Quebecois nurses' actual use of electronic health records. The Doll and Torkzadeh (1998) measure of actual use was originally developed to address the critiques of using objective measures of actual use that focus on quantity (e.g., frequency and duration of use) as being limited in their ability to capture the nature and scope of technology use (DeLone & McLean, 2016; Doll & Torkzadeh, 1998; Maillet, 2014). Actual use as conceptualized by Doll & Torkzadeh (1998) aims to capture three fundamental functions of technologies: 1) decision support, 2) work integration, and 3) customer service. These technology functions are then captured by five dimensions of actual use that include problem solving, decision rationalization, horizontal integration, vertical integration, and customer service (Doll & Torkzadeh, 1998). Maillet et al. (2014) adapted customer service to capture patient care in the context of nursing practice. Their main finding was that perceived usefulness had a positive and significant influence whilst perceived ease of use did not to have a significant influence on nurses' actual use of electronic patient records (Maillet, 2014). The adapted scale was a valid and reliable measure of nurses' actual use of technology in the context of healthcare systems with Cronbach's $\alpha = 0.93$ (Maillet, 2014), demonstrating that the Doll & Torkzadeh measure of actual use can be used in a nursing study.

2.5.3 Summary of Technology Acceptance Models for Use in Nursing Studies

The use of technology acceptance models persists in the efforts to understand mHealth and HIT use in nursing. Recent reviews reinforce the important foundational insights these models provide, particularly in relation to the role of perceived usefulness and perceived ease of use of technologies. These models have evolved in complexity over time, typically by incorporating additional components, in an effort to better understand and explain what influences individuals' use of technologies. The ways of conceptualizing and measuring the concept of technology use also continues to evolve; some have mitigated the limitations of intention to use as a measure of technology use by developing other measures to capture the actual use of technologies. Taking together these contributions and criticisms of technology acceptance models, there is a need to move beyond the common components of existing technology acceptance models in order to incorporate contextual factors of nursing clinical practice and better understand what influences nurses' use of mHealth in the provision of direct patient care.

2.6 Technology and Individual Characteristics Related to Nurses' Use of mHealth, HIT and Research

The use of technology acceptance models as the dominant lens for understanding nurses' use of mHealth and HIT has resulted in a focus on examining the influence of technology characteristics and individual-level characteristics on technology use. In this study, I focus on technology characteristics (perceived usefulness, perceived ease of use, voluntariness of use) and two groups of individual characteristics that have been commonly examined in relation to intention to use and actual use of mHealth and HIT: nurses' demographic characteristics (age, gender, education) and nurses' characteristics related to the technology (previous experience with technology). Because of the limited literature about nurses' characteristics related to mHealth, I draw on the literature from research use/evidence-based practice in nursing where relevant, as this body of work has similarly examined the influence of individual characteristics on nurses' research use/evidence-based practice.

2.6.1 Technology Characteristics

It is no surprise that perceived usefulness and perceived ease of use are among the most commonly examined characteristics of technology that have been examined in relation to their influence on the intention use and actual use of mHealth in nursing and elsewhere, given the previous discussion of the dominant use of technology acceptance models that include these characteristics. In the systematic review by Gagnon et al. (2016) that examined mHealth use in healthcare several technology characteristics were found to influence mHealth (e.g., the design and technical aspects of the technology, compatibility of technologies with existing work processes, reliability and dependability of the technology, interoperability, privacy, security, and legal considerations). However, perceived usefulness and perceived ease of use were found to be the most influential characteristics for mHealth use.

No studies could be identified that examined the influence of voluntariness on nurses' mHealth use, although some studies were found that examined voluntariness as related to nurses' HIT use. In a systematic review of HIT adoption among healthcare providers, voluntariness was among the common factors identified as directly influencing technology use (Li et al., 2013), One study included in the aforementioned review involved nurses although no conclusions could be drawn regarding the influence of voluntariness as a result of measurement error for the variable and its subsequent removal from the final analyses (Zaman, 2015). In another study among physicians in resource-poor environments in Ethiopia, greater perceptions of voluntariness were found to have a negative direct effect on the intention to use telemedicine (Kifle et al., 2010).

Despite inclusion of voluntariness as a moderator in TAM3, UTAUT, and other technology acceptance models, the evidence for its effects remain inconclusive. Notably, many studies reference TAM3 and UTAUT as the rationale for including voluntariness in understanding technology use, despite not testing the moderating role of voluntariness (Dwivedi et al., 2011; Holden & Karsh, 2010; Williams et al., 2015). Among studies that have examined the moderating role of voluntariness, voluntariness has typically been examined as one of a number of other moderator variables (e.g., age and gender in the same block), limiting the ability to distinguish between moderator effects and draw conclusions about the unique role of voluntariness (Williams et al., 2015). Nevertheless, both significant (Bandyopadhyay & Bandyopadhyay, 2010; Wu & Lederer, 2009) and non-significant moderating effects (Bandyopadhyay & Bandyopadhyay, 2010; Payne, 2008; Venkatesh & Davis, 2000) on intention to use technology have been found. Some have suggested that the mixed and sometimes contradicting findings as to the effects of voluntariness may be attributed to differences in cultural context, which, in turn, shape perceived social and professional norms and pressures (Kifle et al., 2010). Alternatively, others have suggested that inconsistent findings may relate to the concept of voluntariness being poorly understood (Tsai et al., 2017).

In summary, perceived usefulness and perceived ease of use are among the most common individual characteristics related to technology use that have been investigated in healthcare informatics and nursing informatics research. With regard to voluntariness, there is incomplete information: while voluntariness is suggested to play a moderating role in a number of technology acceptance models, it is often not analyzed for moderation effects. Moreover, no studies could be identified that examined voluntariness in the context of nurses' use of mHealth which represents an important gap in knowledge given that the typically mandatory nature of technology use in healthcare systems.

2.6.2 Nurse Demographic Characteristics

In this section, nurses demographic characteristics (age, gender, and education) are discussed in relation to mHealth, HIT and research use. Characteristics of individuals using the technology were examined in the review of mHealth use among healthcare professionals by Gagnon (Gagnon et al., 2016). Demographic characteristics were found to influence mHealth use, along with individuals' knowledge and attitudes toward technologies. There are mixed and sometimes conflicting findings related to the influence of these demographic characteristics when considering the technology acceptance literature as compared to the nurses' research use/evidence-based practice literature.

Age has been examined in both technology use and research use studies, but the findings are inconsistent. The literature on nurses' uptake of research has found no association between age and nurses' research use (Estabrooks et al., 2003; Squires et al., 2011). In the UTAUT model, age is one of four variables proposed to moderate the relationships between various predictors and intention to use and use behaviours (Venkatesh et al., 2003); this moderating effect has been observed elsewhere (Sánchez-Mena et al., 2017). With regard to direct effects, studies that examined the use of technologies and mHealth among healthcare professionals have found that age, along with other demographic characteristics, were not associated with the use of HIT (Gagnon et al., 2012) and generally not explored with respect to mHealth use (Gagnon et al., 2016). A study about the use of mHealth by older patients suggests that the influence of age on technology use is likely more complex than initially thought. Guo et al. (2016) examined the relationship between intention to use mHealth services and trade-offs between personalization offered by technology and privacy concerns (Guo et al., 2016). In their study, older users were less concerned about privacy issues, which suggested an increased likelihood of technology use. On the other hand, older users also had less of a desire for personalization, which would suggest a decreased likelihood of technology use (Guo et al., 2016).

The associations between gender and nurses' adoption and usage behaviours of research and technologies is also inconsistent. Gender was not found to have any consistent influence on nurses' research utilization (Estabrooks et al., 2003; Squires et al., 2011). However in the reviews by Estabrooks et al. (2003) and Squires et al. (2011) samples were comprised of 79% or greater female participants, raising the question of whether the effect of gender differences can be detected given the predominance of females in the nursing profession. No studies could be identified that examined the influence of gender on mHealth use by nurses. One study investigated the factors associated with general practitioners' use of an online information retrieval system and found that gender was one of the only two factors associated with usage behaviours, with higher usage rates observed among female participants (Magrabi et al., 2007). These echo the results of other studies that found higher participation rates among female physicians in engaging with an Internet-based continuing medical education intervention (Abdolrasulnia et al., 2004). In a more recent study, gender was a key predictor of nurses' perceived usefulness of electronic health records where female nurses perceived the technology to be more useful (Tubaishat, 2018). Gender is included in UTAUT as a key variable that moderates the relationships between key predictors and intention to use and actual use of technologies (Venkatesh et al., 2003). Venkatesh et al. (2003) suggests that gender works in combination with age, although the interplay between the two remains poorly understood. Many studies about technology use show some effect related to gender, suggesting that it may be important to explore the impact of gender on mHealth use by nurses. Given the exploratory nature of this study, there is an opportunity to examine the role of gender with the caveat that any specific effects might not be detectable due to an expected larger number of female respondents. However, the amount of contribution of gender to a model will be important to help explore this characteristic in future studies.

No studies could be identified that examined the influence of education on mHealth use by nurses. A systematic review of studies about the relationship between nurses' individual characteristics and their use of research, (Estabrooks et al., 2003), found mixed results; education was shown to have a significant, positive influence, as well as to not have any significant influence on research use. More recent work has similarly suggested that no conclusions could be drawn given the equivocal evidence for most education variables examined (Squires et al., 2011). One exception was *type of degree*: having a graduate degree was associated with increased research utilization when compared to bachelor of nursing/diploma degrees, whereas no difference was found in research utilization when comparison bachelor of nursing versus diploma degrees (Squires et al., 2011).

In summary, with regard to age, gender, and education, associations with nurses' research use are mixed (Estabrooks et al., 2003; Squires et al., 2011; Varin et al., 2019). In the technology use literature however, age and gender are associated with technology use (Abdolrasulnia et al., 2004; Magrabi et al., 2007) and found to moderate relationships between various predictors and intention to use and actual use of technologies (Venkatesh et al., 2003). Meanwhile, the effect of education has not been explored in relation to nurses' mHealth use. Prior to the start of this study, to my knowledge, no investigation of nurse demographic characteristics specific to the context of mHealth in nursing had been published.

2.6.3 Nurses' Previous Experience with Technology

No studies could be identified that examined the influence of previous experience with technology on nurses' mHealth use, although some studies were found that examined previous experience as related to nurses' HIT use. In one study, nurses' previous experience using electronic health records and nurses' years of previous healthcare experience were examined in relation to nurses' use of an electronic health record. In their study, Ward et al. (2011) examined whether nurses' patterns of electronic health record use differed with varying levels of previous experience in using electronic health record and previous healthcare experience. It was found that nurses with previous experience using electronic health records had more positive views toward the electronic health record implementation, providing support for *experience as exposure /familiarity to similar technologies* as having a positive influence (Ward et al., 2011). This is in line with previous studies that have found that nurses with previous experience of using electronic patient records and computer use expertise also had more positive attitudes toward the use of electronic health records (Alquraini et al., 2007; de Veer & Francke, 2010; Moody et al., 2004). Qualitative studies that have examined the role of previous experience similarly suggest an association with technology use. A usability study conducted in a resource-limited setting in western Kenya anticipated and confirmed that nurses' previous experience with smartphones was related to their confidence in learning and using a tablet-based decision support and record keeping tool (Vedanthan et al., 2015). This study provides support for *experience as exposure/familiarity to similar technologies* in playing a role in nurses' views, attitudes, and behaviours, that in turn, influence technology use. Similar findings were reflected in a study that examined the use of telehealth to monitor patients with chronic illnesses in four English community health services (Taylor et al., 2015). Interviews were conducted with a total of eighty-four nursing and other point-of-care staff and twenty-one managers and stakeholders (Taylor et al., 2015). The findings suggested that the overall acceptance of telehealth technologies varied widely across different settings. Furthermore, the authors highlighted issues across different levels (organizational, individual) which related to characteristics of the technology. Specifically, previous experience with using other technologies at work (laptops, electronic patient records) were found to both positively and negatively influence perceptions of technology use (Taylor et al., 2015). Participants who viewed the technology use as part of their work acknowledged the potential that technology use could increase their efficiency. In contrast, those who had more negative or apprehensive views expressed concerns about technology use as potentially increasing workload (Taylor et al., 2015).

2.7 The Proposed Conceptual Model

A conceptual model was developed to guide the design and methods used in this study and visually depicted in Figure 2.4. This conceptual model was developed in an effort to articulate nurses' use of mHealth by building on what is known about leadership in relation to nurses' use of mHealth and HIT. The model uses technology acceptance models as a "base" which extends the dominant lens of technology acceptance models by incorporating the view of leadership from nursing and implementation science. Consideration of each model variable was made in relation to recent discourses and critiques of the concepts and in light of mixed findings for a number of the model elements. In the model, implementation leadership characteristics, perceived usefulness, and perceived ease of use of mHealth technologies are suggested to be associated with the intention to use and actual use of mHealth. Nurses' voluntariness of use and individual characteristics that include demographics (age, gender, education) and characteristics related to technology (previous experience with technology) are also considered in this model. Briefly, age, gender, education, and previous experience are posited to have direct effects on nurses' intention to use and actual use of mHealth. In addition, age, gender, education, previous experience, and voluntariness are suggested to exert moderating effects on the associations between key predictor variables (implementation leadership characteristics, perceived usefulness, perceived ease of use) and intention to use and actual use of mHealth. The operationalization of these conceptual model elements is described in detail in Chapter 3.

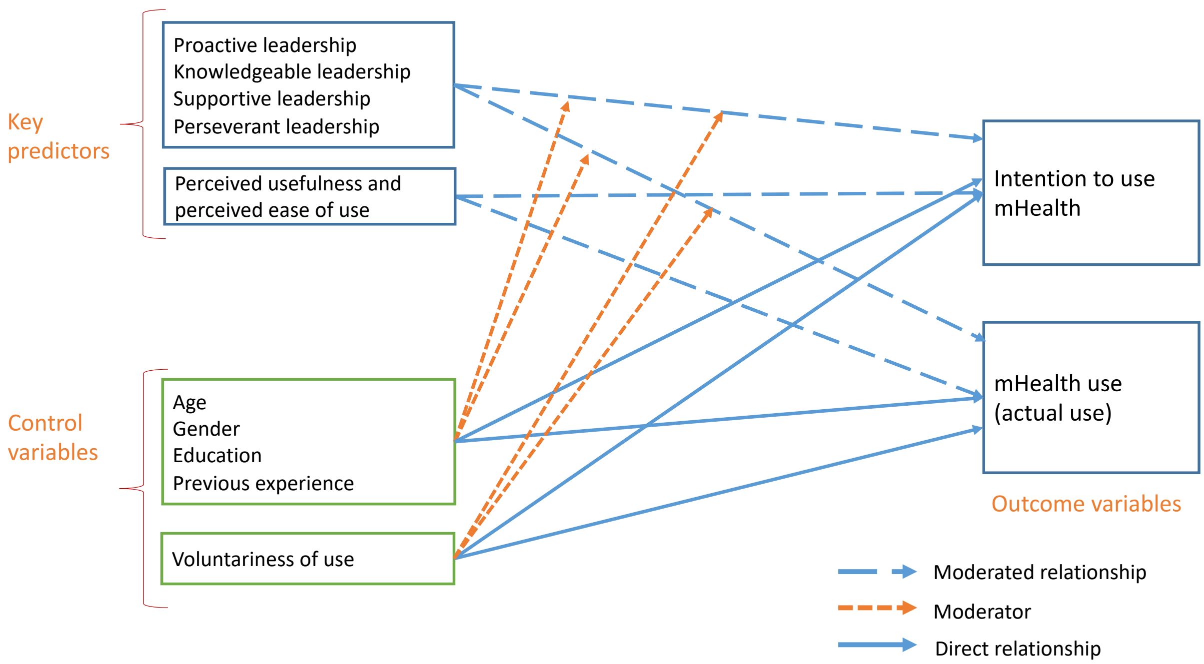

Figure 2.4: Conceptual Model

2.8 Summary of Literature Review

The literature discussed in this chapter considers the role of leadership in implementation and nursing, the current dominant approaches to understanding mHealth and other HIT use in nursing, and the characteristics of individuals that are thought to influence the success of implementing a new innovation – such as mHealth – in practice. There were very few studies that could be identified which examined the potential role of leadership in influencing the use of mHealth among nurses explicitly, although several studies have examined mHealth and other HIT use among nurses and other healthcare professionals. Many of these studies conclude that leadership is important in influencing the use of technologies; these reflect similarities with the recognized importance of leadership as outlined in various implementation science frameworks and models. Moreover, it is well recognized that leadership in nursing is of particular importance as characteristics of leaders have been found to influence nursing outcomes and work environments. The impacts of leadership behaviours on nurses and their work environment can, in turn, influence nurses' attitudes and behaviours towards mHealth use in practice.

There remains limited insight into the detailed nature of leadership despite consistent messaging of the importance of leadership in shaping implementation outcomes such as mHealth use. For example, there is variability in how studies define leadership, what level of leadership is involved, what leadership roles might be most relevant, and what leadership behaviours might best provide "good management support" in the context of supporting nurses' use of mHealth and other innovations introduced in practice. The vague and sometimes inconsistent reference to the concept of leadership presents an important barrier to drawing practical lessons that can inform successful implementation (Reichenpfader et al., 2015).

Beyond the influence of leadership, there are several well-established factors that have been found to influence mHealth, HIT, and research use among nurses and other health care professionals that can be drawn from in order to develop an understanding of the unique contribution of leadership on nurses' mHealth use. These characteristics, drawn from popular technology acceptance models and nurses' research utilization literature, include individuals' perceived usefulness and perceived ease of use of a technology, voluntariness of use, previous experience with technology, and demographic characteristics (age, gender and education). Understanding the unique role of leadership in influencing nurses' mHealth use requires an approach that leverages what is currently known about the factors that influence nurses' use of mHealth, HIT, and research and what is known about the role of leadership and how these influence the use of mHealth in nursing. The conceptual model uses technology acceptance models as a base and was extended to incorporate leadership from the views of nursing and implementation science.

Chapter 3: Methods

The purpose of this study was to examine the effects of implementation leadership characteristics, perceived usefulness, perceived ease of use, technology characteristics, and nurse demographic characteristics on nurses' intention to use and actual use of mHealth in direct patient care. An online survey questionnaire was distributed to Registered Nurses across Canada. Hierarchical multiple regression was used to test the proposed relationships presented in the conceptual model (see Chapter 2).

In this chapter, I discuss the study methods in detail, outlining the research design, sampling strategy, data collection procedures, operationalization of the study variables, data analysis methods, and ethical considerations. To test the proposed relationships shown in the conceptual model (Chapter 2), the following research questions were investigated:

- **Research Question 1:** What is the relationship between (a) implementation leadership characteristics and (b) nurses' intention to use and (c) actual use of mHealth, after controlling for (d) perceived usefulness and perceived ease of use, (e) nurses' previous experience with mobile technology and voluntariness of use, and (f) nurses' demographic characteristics?
- **Research Question 2:** Do nurses' (a) demographic characteristics moderate the relationship between (b) implementation leadership characteristics and (c) nurses' intention to use and (d) actual use of mHealth?
- **Research Question 3:** Do nurses' (a) voluntariness of use moderate the relationship between (b) implementation leadership characteristics and (c) nurses' intention to use and (d) actual use of mHealth?

3.1 Research Design

This was a cross-sectional, exploratory correlational study that examined the above-stated research questions. Study data were collected via an online survey (see Appendix A) that was advertised and distributed to Registered Nurses across Canada.

3.2 Sample

3.2.1 Setting and Participants

Study participants were Registered Nurses (RNs) in Canada who had workplace-provided access to mHealth as a tool to support the delivery of direct patient care. The targeted sample for this study met the following inclusion criteria: 1) Held RN licensure in a Canada; 2) Provided direct patient care in any setting; 3) Had access to an employer-provided mHealth for use in the provision of direct patient care; and 4) Spoke English. RNs who did not provide direct patient care were excluded from this study because the aim of the study was to understand how implementation practices of mHealth influenced nurses' use of this technology in their provision of direct patient care. As such, experiences of RNs who did not provide direct patient care would not reflect experiences related to mHealth use related to patient care provision.

3.2.2 Sample Size

An online, a-priori sample size calculator for hierarchical multiple regression (Soper, 2015) was used to calculate the required sample size and ensure that the study was sufficiently powered. The sample size calculation was set to achieve statistical power = 0.8 and an alpha level <0.05. The entry of blocks into the online calculator were as follows: predictors in set A =

5 nurse characteristics (control variables: age, gender, education, voluntariness, previous experience with technology) and predictors in set B = 3 independent variables (key predictors: implementation leadership, perceived usefulness, perceived ease of use). Moderating effects were of key interest in this study; it was recognized that a critique of many applications of multiple regression is failing to have sufficient statistical power to detect moderation effects (Shieh, 2009). No clear guidance could be found to inform sample size calculation to detect moderating effects, therefore, the goal was to oversample. Thus, the a priori power and sample size calculation in this study was based on eight independent variables in a hierarchical multiple regression without moderating effects (see Section 2.7 for the conceptual model). The study aim was to detect a small effect and to be sufficiently powered to detect moderation effects. As such, the study needed to recruit more than 117 participants. Responses from a total of N=288 participants were used in all regression analyses.

3.3 Data Collection Procedures Using an Online Survey

The following sections describes the data collection procedures in this study, guided by best practice recommendations on conducting online surveys (Dillman et al., 2014; Sue & Ritter, 2011), specific consideration of the study purpose and objectives, and principles of the Tailored Design Method (TDM).

3.3.1 Online Surveys

The use of online surveys in academic research has been accompanied by a growing knowledge base on how to optimise and ensure rigour when employing this method of data collection (Dykema et al., 2013). An online survey was deemed a suitable approach to answer the research questions in this study, drawing upon Dillman's guidance on using TDM for web surveys (Dillman et al., 2014) and Sue and Ritter's (2011) textbook on conducting online surveys as detailed in sections 3.3.2 and 3.3.3 that follow.

3.3.2 Considerations Specific to the Study Purpose

The exploratory nature of the proposed research necessitated a broad reach that did not prematurely narrow to a specific type of clinical service, setting, nor a specific type of mHealth being used. The aim of the study to be broad had two important implications for the study design. First, nonprobability sampling was determined to be appropriate. The dispersed nature of mHealth use by nurses did not make it possible to identify sufficient practice areas, institutions, or organizations where nurses used mHealth routinely and could thus be targeted in the sampling frame as representative of the population. Knowing very little about the nature and scope of nurses' mHealth use prevented the overall understanding of the population characteristics as a reference point to then determine the representativeness of the study sample. Secondly, the use of an online survey made sampling across Canada possible by facilitating easy and timely dissemination of study advertising content. As previously mentioned, an important factor was recognition that the nature and scope of nurses' mHealth use in Canada is not well documented. This meant that there was little means of systematically identifying where and how mHealth is used by nurses. As such, participants' sharing of the online survey to colleagues who fit the inclusion criteria (i.e., snowball sampling) comprised an important strategy to increase the reach of this study to the intended target groups (Beling et al., 2011; Child et al., 2014; Dykema et al., 2013; Hunter, 2012; Mannix et al., 2014; Sue & Ritter, 2011). The use of an easily shareable online survey facilitated a degree of nimbleness as participants could share information about the survey to potential participants by forwarding an email or sharing the survey information via social media. This ease of sharing survey information was not possible with alternative sampling/recruitment methods.

As the target sample were nurses who had workplace-provided access to mHealth as a tool to support their provision of direct patient care, an online survey was deemed appropriate as it was assumed that the target sample would have sufficient technical skills to complete the survey. Finally, the content of the survey instrument did not involve collecting sensitive or personal information. In combination with the use of survey software (versus directly contacting individuals via email addresses), participant anonymity was preserved.

3.3.3 Survey Design Using the Tailored Design Method

The Tailored Design Method (TDM) was used to guide survey development and distribution. TDM is described as an extension of social exchange theory, a sociological theory that aims to explain individual propensities and motivations to differentially engage with certain social behaviours (Dillman et al., 2014). Applied to surveys, the approaches outlined by TDM aim to maximise response rates. At the core of the TDM is the primacy of survey design and implementation and the need for careful consideration of these variables, in order to anticipate and mitigate barriers that may reduce individuals' motivation to participate in surveys (Dillman et al., 2014).

The guidelines that informed the survey design and implementation in this study drew from the latest update of TDM that includes a dedicated section on web survey guidelines (Dillman et al., 2014). This includes sixteen guidelines for designing web and mobile surveys, nine guidelines on web and mobile survey implementation, and seven guidelines on quality control and testing guidelines for web and mobile surveys (Dillman et al., 2014, pp. 349-350). These guidelines address issues such as maintaining key aspects of good paper survey design whilst accounting for how this design will translate to a web or mobile format and managing the functionality and features offered by many online survey software platforms (Fan & Yan, 2010).

As per TDM recommendations to reduce total survey error, the design of the study survey was customised to the survey situation, including considering knowledge about the topic, resources available, types of respondents, and available resources (Dillman et al., 2014). The study used existing measurement instruments that have demonstrated satisfactory validity and reliability and have been tested in similarly educated healthcare professional populations and/or among nurses (Aarons, Ehrhart, & Farahnak, 2014; Aarons et al., 2016; Holden et al., 2016b; Holden & Karsh, 2010; Kim et al., 2015). Generally, these guidelines centre on making the survey as easy to respond to as possible (Dillman et al., 2014). This can be achieved through clear design, easy navigation, consistency of content across advertisements and the survey itself, visual consistency, allowing for flexibility in completion, and building in features that can help respondents troubleshoot any issues that they may encounter (Dillman et al., 2014), in line with other recommendations for web survey design (Handscomb et al., 2016; Scott et al., 2016; Sue & Ritter, 2011).

3.4 Survey Pre-Testing

The 80-item online study survey was informally pre-tested by colleagues of the researcher who were not involved in any aspect of the study but who met inclusion criteria for potential respondents. Individuals who carried out pre-testing were subsequently asked to not participate in the study (Total *n*=5). The study survey content was uploaded to the Qualtrics™ web survey software provided by the University of British Columbia which stores data on Canadian servers. Pretesting focused on the clarity and readability of content, accessibility, presentation and aesthetics, respondent burden, and ease in using and navigating the web survey, and other web-survey related considerations. Individuals who pretested the survey were asked to assess the clarity of instructions and questions, the interpretation of definitions, and how well the questions conveyed the intended message (Dillman et al., 2014; Wolff, 2009). With regard to survey design, feedback was sought regarding the online survey presentation and aesthetics, with particular focus on the variability of survey aesthetics depending on the device, platform, or browser used (Dillman et al., 2014). The burden of responding to the survey was evaluated by eliciting feedback on the length of time it took to complete the survey and consulting the time stamps of the beginning and completion of the survey pretesting. Pre-testers were also asked to provide open-ended feedback on other variables they had identified that affected the ease of completing the survey and any other issues that were not anticipated (Masaro et al., 2012). Upon completion of pre-testing, revisions were made to develop the final version of the study survey. Wording was changed for clarity, typos and grammatical errors were corrected, and order of question presentation was changed. The only changes made to the validated instruments was to replace “technology use” with “mHealth use in nursing” in order to preserve the psychometric properties of validated instruments and in line with recommendations in web survey design and development (Dillman et al., 2014). The pretest version and final version of the study survey were not linked in any way and only the final survey link was made available for distribution.

3.5 Recruitment and Consent

Ethical approval was obtained from the UBC Behavioural Research Ethics Board. The study was advertised via the researchers' contacts in research and higher education organisations, and health and nursing informatics professional groups. The use of social media also constituted a major aspect of recruitment, as nurses have been found to have high rates of social media use (Erer & Çobaner, 2016; Kung & Oh, 2014). Survey advertisements were posted on publicly available professional nursing forums and groups on Facebook, Twitter, and LinkedIn. A dedicated web page (see Appendix B) and Facebook page with survey information were created; Facebook is suggested to be the top social media preference by nurses (AMN Healthcare, 2015). Paid advertisements were used on Facebook and Twitter to increase visibility of the study page and advertisements on these platforms. Information about the online survey were also distributed via specialty discussion lists such as JISCMail, which reaches the emails of mailing list subscribers. Finally, online survey advertisement and participant recruitment were conducted via provincial RN regulatory bodies in Canada. There were important differences in the infrastructure and processes to support recruitment for research studies that were in place in each respective provincial and territorial body (see Appendix C). For instance, regulatory bodies in several provinces (Alberta, Saskatchewan, Manitoba, New Brunswick, and Newfoundland and Labrador) maintained email lists of members who provided permission to be contacted for research purposes as part of their yearly RN registration process. Researchers pay a fee and complete each regulatory bodies' research request process, upon which the regulatory body either provided the mailing list to the researcher or directly contacted their membership with the study advertisement on behalf of the researcher. Recruitment in Nova Scotia was not pursued due to insufficient available funds for payment of the regulatory bodies' research services fee. Recruitment in Quebec was not pursued upon advisement of the regulatory body as the survey was not available in French and the majority of registrants were French-speaking. Notably, the regulatory bodies in British Columbia and Ontario did not facilitate the advertisement of research studies via email and only had the option to facilitate the distribution of paper surveys via mail; distribution via these regulatory bodies were therefore not pursued due to insufficient resources. Finally, Prince Edward Island, Northwest Territories and Nunavut did not have a process in place to facilitate recruitment of their members for research studies. Efforts to recruit in these areas relied on alternative approaches. In Prince Edward Island, recruitment was conducted through Facebook and Twitter. In the Northwest Territories and Nunavut, an agreement was made with the regulatory body for the researcher to contribute a plain language education article for the Registered Nurses Association of the Northwest Territories and Nunavut (RNANTU) monthly newsletter for which the regulatory body allowed the inclusion of a study poster alongside the article; the newsletter was distributed to their registrants.

Interested potential participants were directed to a landing page with information about the aims of the study, the survey structure, and the anticipated length of time it would take to complete the survey (see Appendix B). Potential participants who chose to continue with the survey were required to answer screening questions in order to assess if they had met the eligibility criteria. Participants who met the eligibility criteria were redirected to the informed consent web page. After providing their consent by clicking "Start," participants were able to begin the full survey which included detailed instructions on how to complete the survey and the operational definitions of the terms used in the survey.

An incentive for participation was provided in the form of entry to a gift card draw for each week that the survey was open, an approach found to be successful in encouraging participation among nursing groups (Ulrich et al., 2005) and increasing the odds of response (Edwards et al., 2009). Participants had the opportunity to enter prize draws for electronic gift certificates ($15 CAD weekly for 22 weeks and/or $150 CAD at the end of the study) for the duration of the data collection period. The prize incentive was of a small enough monetary value to ensure that escalating incentive amounts did not unduly influence responses or coerce participants (Cho et al., 2013). Participants who responded to the survey early on (e.g., Week 1) were entered in the weekly prize draw each week until the survey closed. Pit and colleagues (2014) have suggested that larger monetary incentives are effective in increasing participation, with values greater than $5USD classified as "larger cash incentives," which is what was offered in this study (Pit et al., 2014). Data were collected from January to July 2018.

3.6 Measures

The survey used in this study consisted of Doll and Torkzadeh's (1998) Actual Use Scale, Aarons et al.'s (2014) Implementation Leadership Scale, variables drawn from TAM, TAM3 and UTAUT, nurse demographic characteristics, and researcher developed questions on the nature of mHealth use in nursing (e.g., what functions of mHealth were used). In the survey, five sections addressed: 1) the nature of mHealth use in practice, 2) nurses' perspectives about their mHealth use at work, 3) characteristics (e.g., job title) of leaders responsible for implementing mHealth, 4) previous experience with mHealth and other mobile technologies, and 5) nurses' individual characteristics. A summary of study variables is shown in Table 3.1. Description of the measures are provided in the sections that follow.

Table 3.1 Overview of Study Variables

Study Variables	**Definition**
Outcome Variables	Nurses' use of mHealth • Intention to use • Actual use
Key Predictors	Implementation leadership • Implementation leadership characteristics Technology characteristics • Perceived usefulness • Perceived ease of use
Control Variables	Technology characteristics • Voluntariness Nurse demographic characteristics • Age • Gender • Education Nurse characteristics related to technology • Previous experience with work mHealth • Previous experience with non-work mobile technology

To assess the component structures of scales used, principal component analyses (PCA) were conducted on the scales used to measure intention to use mHealth, actual use of mHealth, perceived usefulness, perceived ease of use, and voluntariness. The Kaiser–Meyer–Olkin measure was calculated for each scale where values above a minimum of 0.5 verified adequate sampling (Field, 2009; Kaiser, 1974). Bartlett's test of sphericity were run for each respective scale to assess whether correlations between items were sufficiently large to support PCA (indicated by statistically significant result of $p < .05$) (Field, 2009). For all scales used, the sample size and correlations between items were found to be satisfactory to conduct a PCA as indicated by the KMO statistics and Bartlett's test of sphericity. Adequacy of sample size for conducting a PCA on the various scales was assessed as per guidance outlined by MacCallum et al. (1999) who argued for the importance of other aspects of the study design beyond the sample to variable ratio in determining sample size adequacy. It is suggested that with communalities in the 0.5 range, a sample between 100 to 200 is deemed sufficient when there are well-determined factors (i.e., relatively fewer factors with few indicator variables). Mean communalities of all scales used in this study were above the 0.5 range, suggesting that a sample size of N=288 is sufficient to conduct the PCAs described in this chapter. Cronbach's alpha coefficients were calculated for all scales; minimum recommended values are in the range of .7 to .8 (Field, 2009; Osborne, 2008). Tables summarizing the component structure statistics for all scales used in each group of variables (outcome, key predictors, control) can be found in Appendix D. Reliability statistics and additional information about validity testing are presented in each section.

3.6.1 Outcome Variables: Nurses' Use of mHealth

The outcome variables were nurses' intention to use mHealth and nurses' actual use of mHealth. A detailed description of the development, validity, and reliability of the outcome variables are outlined in the following sections.

3.6.1.1 Nurses' Intention to Use mHealth

Intention to use refers to nurses' plan to use mHealth as part of their clinical practice. The intention to use a technology is often considered a precursor and/or proxy for actual technology use behaviours and considered as the latter, in this study. The measure for intention to use was adapted from Venkatesh and Bala's (2008) Technology Acceptance Model 3 (TAM3) (as per Section 2.5) and was comprised of three items (see Appendix A, Section B, items 12-14). Respondents were instructed to indicate the extent of agreement with these statements on a 7-point Likert scale, from 1 (strongly disagree) to 7 (strongly agree), with higher scores indicating stronger intentions to use mHealth. The variable was formed by taking the mean of the items. Psychometric assessment of the measure for intention to use has consistently demonstrated high internal consistency and reliability, with Cronbach's α for intention to use consistently greater than .8 across studies and time periods (Venkatesh, 2015; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000).

In this study, the intention to use scale had high internal consistency, Cronbach's α =.85, exceeding recommendations of values to be in the range of .7 to .8 (Field, 2009; Osborne, 2008). In the PCA of intention to use, one component was extracted with an eigenvalue of 2.35; this component explained 78.28% of the variance. The scree plot converged on a one-component solution supporting the decision to retain the 1-component structure in the final analysis. Results of the principal components and reliability analyses of the intention to use scale support its internal consistency and is consistent with much prior research (Agarwal et al., 2000; Davis, 1989; Davis et al., 1989; Mathieson, 1991; Venkatesh, 2015; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000).

3.6.1.2 Nurses' Actual Use of mHealth

The debate related to the correlation between intention to use and actual use behaviours, as previously discussed in Section 2.5.2, was a consideration in this study. To mitigate the limitations of using only intention to use as the measure of nurses' mHealth use, the Doll and Torkzadeh's (1998) measure of system-use adapted by Maillet (2014) was used. The adapted scale[3] was found to be a valid and reliable measure of nurses' actual use of technology in the context of the Canadian healthcare system with Cronbach's $\alpha = 0.93$. Maillet's measure of actual use is a 14-item scale with five sub-scales that refer to the specific purpose for using the technology: problem solving, decision rationalization, horizontal integration, vertical integration, and patient care. Each item is scored on a 5-point scale indicating the degree to which the respondent perceives each statement to apply to them, ranging from 0 (not at all) to 4 (a great deal). The sum of all items is computed to create the actual use total score, where higher scores indicate greater use of mHealth for specific purposes (Doll & Torkzadeh, 1998; Maillet, 2014; Maillet et al., 2015).

For the actual use scale, a PCA was conducted on the 14 items with oblique oblimin rotation. Two components were extracted which explained 67.74% of the variance. The scree plot converging on a two-component solution which supported the decision to retain two components in the final analysis. The two extracted components centred around support for problem solving and decision-making (problem solving, decision rationalization) and work coordination and integration (horizontal and vertical integration). These findings do not reflect the 5-dimension structure of actual use as proposed by Doll and Torkzadeh (1998). However,

[3]Customer service was adapted by Maillet (2014) to capture patient care.

Doll and Torkzadeh (1998) suggested that the nature of the sample may determine the number of factors of the actual use scale, as distinguishing between the dimensions of actual use may be more unclear among certain groups. For this study sample, it is possible that nurses may not distinguish between problem solving and decision rationalization dimensions as these processes are inextricably linked in nurses' provision of direct patient care: one must be able to rationalize decisions made as a part of clinical problem solving. Similarly, nurses may not distinguish between horizontal integration, vertical integration, and patient care, as it can be argued that these processes all centre on providing comprehensive and continuous person-centered care where functioning as part of a multidisciplinary team is a key characteristic. Indeed, the two component solution for the actual use scale are in line with findings by Maillet (2014). In the current study, the Cronbach's α =.93 for the support for problem solving and decision-making component and α =.89 for the work coordination and integration component of the actual use scale, which exceed recommendations of values to be in the range of .7 to .8 to be considered satisfactory (Field, 2009; Osborne, 2008). Both the structure and pattern matrices are reported as per recommendations by Field (2009) when conducting PCA with oblique rotation (see Appendix D). Briefly, the pattern matrix provides information on variable loadings on extracted components, providing information about the component structure of the scale. Similar patterns of variable loadings on components reflected in structure matrices provide further support for the component structure of the scale. Moreover, examining the common themes in both matrices provide information about what the components represent and aid interpretation (Field, 2009). A summary of the independent variables and corresponding conceptual and operational definitions are provided in Table 3.2.

Table 3.2 Outcome Concepts and Operational Definitions

Variable and Conceptual Definition	Operational definition
Intention to use (mHealth) Intention to use refers to nurses' plan to use the mHealth as part of their work.	• Three items asked nurses about their intentions to use mHealth in their work. The items were measured on a 7-point Likert scale, from 1 (strongly disagree) to 7 (strongly agree). • The variable was formed by taking the mean of the items. Higher scores indicate stronger intentions to use the mHealth. • The survey items can be found in Appendix A, Section B, items 12-14.
Actual use (of mHealth) Actual use refers to nurses' reported use of mHealth for specific purposes, as part of their work.	• Doll and Torkzadeh's 14-item scale was used that asked about the degree to which the respondent perceives each statement related to the use of specific mHealth functions to apply to them. This multidimensional measure of actual use comprised of five sub-scales that refer to specific components of technology functions: problem solving, decision rationalization, horizontal integration, vertical integration, and patient care. • Items were measured on a 5-point Likert scale, ranging from 0 ('not at all') to 4 ('a great deal'). The variable was formed by taking the sum of the items. Higher scores indicate greater actual use of mHealth. • The survey items can be found in Appendix A, Section B, Use scale items 1-15.e.

3.6.2 Key Predictor Variables

The key predictor variables in this study were implementation leadership characteristics, perceived usefulness, and perceived ease of use of technology. A detailed description of the development, validity, and reliability of the predictor variables are outlined in the sections that follow.

3.6.2.1 The Implementation Leadership Scale

Implementation leadership characteristics were measured using the staff version of the Implementation Leadership Scale (ILS) (Aarons, Ehrhart, & Farahnak, 2014). The ILS asks respondents to reflect on the specific leadership behaviours of the "first-level" leader in charge of implementation of mHealth, recognizing their key positioning to facilitate implementation

(Aarons, Ehrhart, & Farahnak, 2014; Schein, 2010). Implementing mHealth and overseeing this process at the point of care is often tasked to leaders who have a role in supervising those who provide direct patient care (Aarons et al., 2015). This study explored the link between the implementation leadership behaviours of the person in charge of implementation rather than the titles of those individuals. As such, reference to a specific leadership title was avoided in the survey as variability and uncertainty as to the specific titles of individuals who might oversee the mHealth implementation at the local level (e.g., educators, local managers, temporary project leaders, project champions) was expected.

The ILS is a 12-item scale with four sub-scales that refer to specific leadership behaviour traits of first-level leaders: proactive leadership, knowledgeable leadership, supportive leadership, and perseverant leadership. There are three items per sub-scale. Each item is scored on a 5-point scale indicating the degree to which the leader in charge of implementation in the unit/department performs specific behaviour, ranging from 0 (not at all) to 4 (to a very great extent). A score for each subscale was computed from the mean of items for each of the scale dimensions. The mean of the subscale scores was then computed as the total ILS score (Aarons, Ehrhart, Farahnak, et al., 2014; Aarons et al., 2016).

Principal components analysis (PCA) was conducted on the 12 items with oblique promax rotation congruent with methods from other studies (Aarons, Ehrhart, & Farahnak, 2014). An initial PCA extracted one component which had an eigenvalue over Kaiser's criterion of 1 and explained 74% of the variance which did not replicate the original factor structure. As the ILS is hypothesized to have a four-dimensional structure, a PCA was conducted that specified a 4-component model. This approach was taken by Aarons et al. (2014) in the development and psychometric assessment of the ILS. The PCA specifying a 4-component model had one component with an eigenvalue of 8.88 and explained 74% of the variance. Component 2 had an eigenvalue of 0.75 explaining 6.24% of the variance, Component 3 had an eigenvalue of 0.57 explaining 4.76% of the variance, and Component 4 had an eigenvalue of 0.46 explaining 3.80% of the variance. The variables in each of the extracted components reflected the theorized dimensions of the ILS and the four-component solution was retained to be used in the final analysis (see Appendix D for the pattern matrix). The structure matrix shows the same pattern of component loadings as found in the pattern matrix. The Cronbach's α were high for all subscales and the highest variable loadings for each component corresponded with the respective dimensions of ILS that groups of items represented (see Appendix D for the structure matrix). Cronbach's α = .95 for the component knowledgeable leadership, α = .94 for the component supportive leadership, α = .90 for the component proactive leadership, and α = .95 for the component perseverant leadership of the ILS; all are considered satisfactory (Field, 2009; Osborne, 2008). These results are consistent with the initial validation of the ILS where Cronbach's α greater than 0.9 for all subscales and the total scale were obtained (Aarons, Ehrhart, & Farahnak, 2014) and reflected in a number of other studies (Aarons et al., 2016; Guerrero et al., 2020; Torres et al., 2017), providing support for the internal consistency and reliability of the ILS.

3.6.2.2 Perceived Usefulness

Perceived usefulness refers to nurses' perceptions of how useful mHealth is in their work. The measurement of perceived usefulness was adapted from Venkatesh and Bala's (2008) TAM3 study, which is the same instrument from which intention to use was drawn. These measures are comprised of a subset of items from Davis et al.'s (1989) early TAM studies which have demonstrated good reliability and validity in a large number of studies (Marangunić & Granić, 2015). Items were adapted by this author to specify mHealth as the type of technology used, in line with recommendations by Davis et al. (1989). Respondents were instructed to indicate the extent of agreement with the instrument items on a scale from 1 (a very small extent) to 7 (a very large extent). The perceived usefulness variable was measured with a set of four items, with higher scores indicating greater perceptions of usefulness. The variable was formed by taking the mean of the items. The measure for perceived usefulness has been demonstrated to have acceptable reliability and internal consistency with Cronbach's α greater than 0.8 across different studies and time periods (Venkatesh & Davis, 2000). A PCA was conducted on the 4 items of perceived usefulness. One component was extracted with an eigenvalue of 3.352; this component explained 83.81% of the variance. The perceived usefulness scale had an acceptable reliability with a Cronbach's α =.93 (Field, 2009; Osborne, 2008). Results of the principal components and reliability analyses of the perceived usefulness scale support its internal consistency and reliability, as has been found in previous studies (Venkatesh, 2015; Venkatesh & Bala, 2008; Venkatesh & Davis, 2000).

3.6.2.3 Perceived Ease of Use

Perceived ease of use refers to one's perception of how it is to use the mHealth. Similar to the measure of perceived usefulness, the measure of perceived usefulness was adapted from Venkatesh and Bala's (2008) TAM3 study and is comprised of a subset of 4 items from Davis et al.'s (1989) early TAM studies. Also similar to the measure of perceived usefulness, items were adapted to specify mHealth as the type of technology used (Davis, 1989). Respondents were instructed to indicate the extent of agreement with the items on a scale from 1 (a very small extent) to 7 (a very large extent). Perceived ease of use was computed by taking the mean of the four items; higher scores indicate greater perceived ease of use. The measure for perceived ease of use has been demonstrated to have acceptable reliability and internal consistency with Cronbach's α greater than 0.8 across studies and time periods (Venkatesh & Davis, 2000).

The PCA conducted on the four items of the perceived ease of use scale yielded one component with an eigenvalue of 2.847, explaining 71.18% of the variance. The perceived ease of use scale met reliability requirements with a Cronbach's α =.86 (Field, 2009; Osborne, 2008). Results of the PCA reliability analysis of the perceived ease of use scale support its internal consistency and reliability, similar to previous studies (Venkatesh, 2015; Venkatesh & Davis, 2000). The conceptual definitions, operational definitions, and survey items that were used to measure the key predictor variables (implementation leadership characteristics, perceived usefulness, perceived ease of use) are summarized in Table 3.3 below.

Table 3.3 Key Predictor Concepts and Operational Definitions

Variable and Conceptual Definition	Operational definition
Implementation leadership characteristics Aspects of leadership – indicated by specific leadership behaviours – that are thought to influence the implementation of mHealth.	*Implementation Leadership Scale (ILS)* • This12-item scale asked respondents to indicate their degree of agreement that their clinical leader performs a number of specific behaviours. The items were measured on a 5-point Likert scale, from 0 ("not at all") to 4 ("to a very great extent"). • The ILS is a multidimensional scale comprising the following aspects of leadership: proactive leadership, knowledgeable leadership, supportive leadership, and perseverant leadership. • A mean score was computed for each of the scale dimensions. The mean of the subscale scores was then computed as the total ILS score. Higher scores indicate stronger staff perceptions of demonstrated leadership behaviours of clinical leaders. • The survey items can be found in Appendix A, Section C3, items 1-12.
Technology characteristics Characteristics of technology that are known to be associated with technology use. In this study, these characteristics refer to the combination of nurses' perceptions of how useful mHealth is in their work (perceived usefulness) and how easy mHealth is to use in their work (perceived ease of use).	*Perceived usefulness (PU)* • Four items that asked respondents to indicate their extent of agreement with the instrument items on a scale from 1 (a very small extent) to 7 (a very large extent). • The variable was formed by taking the mean of the 4 items. • Higher scores indicate greater perceptions of usefulness. • The survey items can be found in Appendix A, Section B, items 4-7. *Perceived ease of use (PEOU)* • Four items that asked respondents to indicate their extent of agreement with the instrument items on a scale from 1 (a very small extent) to 7 (a very large extent). • The variable was formed by taking the mean of the 4items. Higher scores indicate greater perceptions of ease of use. • The survey items can be found in Appendix A, Section B, items 8-11.

3.6.3 Control Variables

The following sections describe the control variables in this study. Control variables included voluntariness (a technology characteristic), previous experience with technology (individual characteristic related to technology), and nurse demographic characteristics.

In this study, two variables were used related to technology: voluntariness of use and previous experience with mobile technology, and three demographic characteristics were considered (age, gender, education). The conceptual definitions, operational definitions, and survey items that were used to measure the control variables (previous experience with mobile technology, voluntariness, nurse demographic characteristics) are summarized in Table 3.4, below.

3.6.3.1 Voluntariness

Voluntariness refers to the degree to which the use of mHealth is a mandatory or a voluntary component of nurses' jobs. Three items were used to measure voluntariness, drawn from Moore and Benbasat (1991). All items were measured on a 7-point Likert scale (1 = strongly disagree and 7 = strongly agree). The variable was formed by taking the mean of the three items. The measure for voluntariness has been demonstrated to have acceptable internal consistency with Cronbach's α greater than 0.8 across studies and time periods in previous studies (Venkatesh, 2015; Venkatesh & Davis, 2000).

A PCA was conducted on the 3 items. The scree plot converged on a one component solution and one component was extracted with an eigenvalue of 2.608; this component explained 86.94% of the variance, supporting the decision to retain the 1-component structure in the final analysis (see Appendix D). The voluntariness of use scale met reliability requirements with a Cronbach's α =.924 (Field, 2009; Osborne, 2008).

3.6.3.2 Previous Experience with Mobile Technology

Previous experience with mobile technology was conceptualized in this study as the two forms of previous experience that have been identified in the literature: experience as exposure/familiarity to similar technologies and experience with the specific technology in question. Both forms of experience have been associated with technology use behaviours and found to moderate the effects of other variables. However, no studies could be identified that made the distinction between the different forms of experience, nor examined if there is a difference in effects between the two.

Previous experience was conceptualized in this study similar to previous studies, with experience representing the passage of time from the initial use of the technology up to the present (Venkatesh et al., 2003; Venkatesh et al., 2012). Previous experience *as exposure/familiarity to similar technologies* was operationalized by asking for an estimate of the month and year that the nurse first used mobile devices outside of work (see Appendix A, Section D1). The total number of months since first use of mobile devices outside of work were computed and used in the analyses as done by Venkatesh et al. (2012). Previous experience in the form of *experience with the specific technology in question* was operationalized by asking for an estimate of the month and year that the nurse first had access to employer-provided mHealth for use in their current nursing job from which the total number of months was computed and used in the analyses (2012).

3.6.3.3 Nurse Demographic Characteristics

A number of individual characteristics have been found to have either direct and/or moderating effects on individual's intention to use and use of technology. In this study, nurse demographic characteristics included *age, gender,* and *education*. These individual characteristics were identified in both the technology use literature and nurses' research utilization literature. As discussed in Chapter 2, the effects of some variables are inconsistent across the different fields.

Age in years was calculated from the participant's report of their year of birth and month of birth. Studies on nurses' use of research found no association between age and nurses' research use (Estabrooks et al., 2003; Squires et al., 2011). However, the role of age has been identified in the technology use literature as influencing individuals' perceived ease of use, perceived usefulness, attitudes towards technologies (Venkatesh & Bala, 2008; Venkatesh et al., 2003) and as moderating the effects of key relationships in other technology acceptance models (Venkatesh et al., 2003).

Gender was collected by asking respondents to identify as male, female, or other. Previous research has found differential attitudes toward and actual use of technologies that are influenced by shaped by gender roles and norms (Venkatesh & Davis, 2000; Venkatesh et al., 2003). A recent meta-analysis found gender differences in attitudes towards technology, with men showing more favourable beliefs about the value of technology use and greater self-confidence in the ability to effectively learn and use technology as compared to women (Cai et al., 2017). Furthermore, Cai et al. (2017) found enduring differences related to beliefs of the value of technology use by gender over the span of 20 years, although there was a noticeable reduction in difference of perceptions of self-efficacy by gender. The inclusion of gender was informed by technology use studies that have found gender roles to moderate the relationships between perceived usefulness and intention to use, and perceived ease of use and intention to use (Venkatesh & Davis, 2000; Venkatesh et al., 2003), although these studies applied binary conceptualizations of gender (male and female). Specifically, it has been found in previous work that perceived usefulness plays a greater role in deciding whether or not to use a new technology among men, whereas perceived ease of use played a greater role in this decision-making among women (Venkatesh & Morris, 2000). Furthermore, it has been suggested that gender and age appear to work in combination although the interplay between age and gender is poorly understood (Venkatesh et al., 2003).

Education was collected by asking participants to indicate the highest type of nursing degree that the individual had completed (RN diploma, Bachelor of Nursing, Master of Nursing, or PhD). Studies of nurses' research utilization have found that having a graduate degree was associated with increased research utilization as compared to diploma/bachelor of nursing degrees, whereas no difference was found when comparing diploma versus bachelor of nursing degrees (Squires et al., 2011).

The conceptual definitions, operational definitions, and survey items that were used to measure the control variables (previous experience with mobile technology, voluntariness, nurse demographic characteristics) are summarized in Table 3.4, below. Education and gender were recategorized into binary variables and this process is described in Section 3.7.1.

Table 3.4 Control Variables and Operational Definitions

Variable and Conceptual Definition	Operational definition
Voluntariness of use Voluntariness of use refers to nurses' perceptions of the degree of individual choice they have in the decision to use mHealth as part of their work. The use of mHealth can be mandatory or an optional choice that is left to the discretion of the nurse.	• Three items asking the degree of agreement with statements related to the voluntary use of the mHealth. All items are measured on a 7-point Likert scale (1 = strongly disagree and 7 = strongly agree). . • The variable was formed by taking the mean of the 3 items. • The survey item can be found in Appendix A, Section B, items 1-3.
Previous experience with mobile technologies Refers to nurses' previous experience with using similar technology as well as previous experience with using the specific mHealth that they currently use as part of their work	*Previous experience (with similar technology)* • One item asking about when the non-work mobile technology was first used by the individual, measured in years and months. • The survey item can be found in Appendix A, Section D1. *Previous experience (with work mHealth)* • One item asking about when the mHealth technology was first introduced to the individual, measured in years and months. The survey item can be found in Appendix A, Section A1.
Nurse demographic characteristics Individual-level characteristics of nurses that capture demographic characteristics that have been found to be associated with either nurses' research utilization or technology use. This includes age, gender and education.	*Age* One item asking to identify the year of birth and month of birth. Age in years was computed from the year and month of birth provided. *Gender* One item asking to identify gender: 0 = male; 1 = female; 2 = other; 3 = prefer not to say This variable was dichotomized into "male" and "female" groups for inclusion in various analyses. *Education* One item asking the highest level of nursing education completed by the respondent. Response options were: 1 = Nursing diploma 2 = Bachelor's degree 3 = Master's degree 4 = PhD in nursing 5 = Other This variable was dichotomized into "RN diploma/Bachelor of Nursing" group and "Nursing Graduate Degree/Other" group for inclusion in various analyses.

3.7 Data Analysis

3.7.1 Data Screening and Preparation

Data were extracted from the online Qualtrics™ software into a password protected SPSS 26.0 database and the raw data were screened for missing, incorrect, questionable response patterns responses, and data entry errors. After initial screening, frequency and simple cross-tabulations were used to examine the distributions of the demographic and study variables.

The screening questions that potential participants were asked to complete prior to starting the survey was mostly successful in ensuring that participants who proceeded were RN registrants. Nevertheless, examining the responses to the question asking about type of nursing registration revealed 35 participants who did not meet the inclusion criteria as they were Registered Practical Nurses (n=7), Nurse Practitioners (n=27), and Registered Midwives (n=1). As per the rationale for the inclusion criteria restricting participants to RNs, it is arguable that the influence of leadership characteristics on non-RN registrants' behaviour related to use of mHealth in practice would be different from RNs. For example, Nurse Practitioners have more professional autonomy, and so, characteristics of leaders implementing mHealth may be less relevant in influencing their mHealth use behaviours. Similarly, Registered Practical Nurses' different scope of practice may limit their ability to access and be provided with mHealth as compared to RNs. The participant who indicated registration as a Registered Midwife was removed due to inconsistencies in survey responses (indicated Registered Midwife as licensure and indicated Registered Practical Nurse as highest educational qualification).

The categorical variable for education was dichotomized because 89.9% of responses were captured by the two categories of diploma and Bachelor of Nursing; use of a dichotomous variable therefore allowed for inclusion in multiple regression analyses without creating dummy variables for the categories with very small numbers and percentages (Field, 2009; Tabachnick & Fidell, 2013). For nursing education, four options to indicate levels of highest educational qualification were originally indicated on the survey: RN diploma, Bachelor of Nursing, Masters in Nursing, PhD in Nursing, and Other. Text responses provided to accompany the "Other" option reflected advanced practice diplomas, certification, and training in nursing. Means plots were produced which suggested consistent linear relationships between the four original nursing education categories and both outcome variables. However, analyses of variance (ANOVA) showed no significant differences between groups for intention to use $F(5,338) = 0.45$, $p > .05$ and actual use $F(5,338) = 0.49$, $p > .05$ (Field, 2009; Tabachnick & Fidell, 2013). Examination of the means plots for both outcome variables with education categories did not reveal any obvious patterns for how to categorize nursing education groups into a dichotomous variable. As there was no clear indication from the statistics as to how to best dichotomize nursing education, a theoretical justification is made. Nursing education was dichotomized as RN diploma/ Bachelor of Nursing group and Nursing Graduate Degree/Other group based on findings from the research utilization literature where having a graduate degree has been associated with increased research utilization when compared to diploma and bachelor of nursing degrees, but no differences were found when comparing research utilization between bachelor of nursing and diploma degrees (Squires et al., 2011).

The categorical variable for gender was dichotomized because 97.1% of responses were captured by the two categories of Female and Male. For gender, four options were originally indicated on the survey: Female, Male, Prefer not to say, and Other. Given the small percentage (2.9%) of non-binary and "prefer not to say" responses, gender was dichotomized into the categories Female and Male. Responses from individuals who identified as non-binary were removed.

3.7.2 Handling of Missing Data

As ILS was the key predictor of interest, it was not possible to conduct regression analyses with cases (i.e., participants) that were completely missing an ILS score; these cases were removed from analyses (n = 65). After removal of cases that did not contain ILS scale questions, missing data for all other variables in the model was < 1% and there were no items that were consistently missing (had more than 1% missing for that item); there were at most 2 items missing from each case (each participant skipped no more than 2 of the 80 items) (Tabachnick & Fidell, 2013). All cases were retained for analysis as per recommendations on handling missing data when < 5% of data are missing for an overall survey and maintaining a large sample size whilst minimizing the influence of missing data (Tabachnick & Fidell, 2013). After removal of all cases as indicated in this section and Section 3.7.1, the final sample size for the study was N = 288.

3.7.3 Descriptive Statistics

Descriptive statistics (frequencies, percentages, means, standard deviations, ranges) were obtained for each study variable, and used to assess if the data met the assumptions required to perform hierarchical multiple regression analyses (Field, 2009; Tabachnick & Fidell, 2013). The variables perceived usefulness, perceived ease of use, previous experience with work mHealth, and voluntariness appeared potentially skewed upon examination of histograms. Scatter plots were produced and reviewed for each of these variables, plotted against the two outcome variables. The scatter plots showed no evidence of curvilinear relationships, which, along with assessment of residuals scatterplots and bivariate correlations (described in detail in Chapter 4), supported inclusion of perceived usefulness, perceived ease of use, previous experience with work mHealth, and voluntariness in the multiple regression analyses (Field, 2009; Tabachnick & Fidell, 2013). Furthermore, it is worth noting that for predictor variables, only independence between variables and errors are assumed (Fox, 2015, p. 318). This is commonly confused with the assumption that predictors have to be normally distributed when in fact, no assumptions are made about distributions of predictors (Field, 2009).

3.7.4 Bivariate Correlations

The requirements to perform parametric tests were examined next. Bivariate correlation analyses via Pearson's r, point-biserial correlations (r_{pb}), and phi (φ) were computed to examine the relationships between pairs of variables and to assess for multicollinearity (Field, 2009; Polit & Beck, 2008). Cohen (1988) provided the most commonly referenced guidelines for interpreting the magnitude of effect sizes of correlation coefficients. Correlation coefficients in the order of .10, .30, and .50 or higher are considered small, medium, and large effect sizes, respectively (Cohen, 1988, pp. 77-81). More recent work has attempted to develop empirical guidelines for interpreting the magnitude of correlation coefficients, developed through the analysis of large, diverse meta-analytic studies in psychology (n=380 studies) (Hemphill, 2003). This work to extend Cohen's benchmarks aims to address suggestions that existing guidelines by which effect sizes are compared may be "unrealistically large and 'inappropriate'" (Meyer et al., 2001). In particular, it is suggested that Cohen's (1988) benchmark of $r = .50$ to indicate a large effect size has been infrequently found in research studies in psychology, suggesting that some instances might warrant a lower value (Hemphill, 2003). Empirical guidelines suggested by Hemphill (2003) indicates correlations of <.20 to belong in the lower third of effect sizes found, correlations of .20 to .30 falling in the middle third, and >.30 falling in the upper third in magnitude. Interpretation of effect sizes in this study were, therefore, informed by both Cohen's (1988) and Hemphill's (2003) guidance on effect sizes. Upon completion of the data screening steps as described in this section, all other assumptions to conduct hierarchical multiple regression analyses were deemed to be sufficiently met. Details of the diagnostics that were conducted can be found in Chapter 4.

3.7.5 Hierarchical Multiple Regression and Moderation Analyses

Hierarchical multiple regression was used as the main method of data analysis to answer the study research questions. Diagnostics of the *intention to use* and *actual use* regression models were conducted to assess model assumptions; all assumptions were met. These diagnostic assessments are in line with established conventions and include examination of: Q-Q plots and residuals scatterplots to examine normality of residuals and to visually identify potential outliers; standardized residuals, Leverage values, Cook's distance and Mahalanobis distance to assess model fit with the data and identify potentially influential cases, Durbin-Watson statistic to assess independent errors (i.e., independence of residual terms for any two observations), intra-class correlations to assess independence of observations, multicollinearity between independent variables (indicated by multicollinearity indices (VIF (<10) and tolerance (>.1)), homoscedasticity (by examining the scatter plot of the standardized errors (Y-Axis) against the standardized predicted Y (X-Axis), skew, kurtosis, and normal distribution of residuals (Field, 2009; Pallant, 2016; Tabachnick & Fidell, 2013). While some collinearity among independent variables is unavoidable, the absence of extreme multicollinearity avoids problems related to: a) the ability to discern the individual importance of each variable, b) untrustworthiness of beta coefficients (due to increased standard errors of beta coefficients with increased collinearity), and c) limiting the size of *R* (due to more than one variable accounting for the same rather than unique variances). Due to the abovementioned reasons, the absence of extreme multicollinearity in the model variables was an important assumption to have met in this study. Detailed results of these diagnostics are outlined in the findings presented in Chapter 4.

The creation of the regression model and the sequence in which variables were entered into the model were theoretically justified, as detailed in the development of the conceptual model (Chapter 2) and guidance on order of variable entry when conducting a hierarchical multiple regression (Field, 2009; Tabachnick & Fidell, 2013), known predictors were first entered into the model, followed by the key predictors of interest. In this study, separate sets of models were run for each of the two outcome variables: (1) intention to use mHealth and (2) actual use of mHealth. For each outcome variable, the order that the variables were entered in the regression models were as follows:

- Model 1: control variables
- Model 2: control variables + voluntariness
- Model 3: control variables + voluntariness + perceived usefulness and perceived ease of use

- Model 4: control variables + voluntariness + perceived usefulness and perceived ease of use + implementation leadership characteristics
- Model 5: control variables + voluntariness + perceived usefulness and perceived ease of use + implementation leadership characteristics + interaction term.

This order of model entry aimed to examine the unique effect of implementation leadership characteristics over and above the effect of control variables, perceived usefulness, and perceived ease of use (Research Question 1) and whether there were significant moderating effects of nurse demographic variables (Research Question 2) and voluntariness (Research Question 3) on implementation leadership. For all analyses, the goodness of fit of the model was assessed by examining the proportion of variance accounted for by the full model with the R^2 statistic, model parsimony examined with the adjusted R^2 statistic, proportion of variance attributable to each variable with the R^2 change statistic, and changes in the dependent variable per increase in standard deviation in each independent variable by examining beta coefficients; these statistics are in line with accepted conventions for conducting multiple regression analyses (Field, 2009; Tabachnick & Fidell, 2013).

To test for moderating effects, an interaction term was produced for each interaction of interest, which is the product of the proposed moderator variable and the key predictor variable they are thought to influence (Aiken et al., 1991). Six interaction terms were computed and used in the regression analyses for each of the two outcome variables: ILS*age, ILS*gender, ILS*education, ILS*previous experience with work mHealth, ILS*previous experience with non-work mobile, and ILS*voluntariness. Each interaction term was tested independently in Model 5 for each outcome variable. Non-significant interaction terms were dropped in the final models. As no differences in outcomes have been found with comparisons of centered outcome variables (creation of a new variable by subtracting the variable mean so that the new mean is zero) and non-centered outcome variables (preserving the original variable values; the mean will not be zero), this study used non-centered outcome variables to preserve the original scale of the variable, as per recommendations by Aiken and West (1991).

Local effect sizes resulting from the addition of variables to the regression models were calculated for significant variables. A variation of Cohen's f^2 as described by Selya et al. (2012) was calculated using Soper's online effect size calculator for hierarchical multiple regression (Soper, 2015), which provides a measure of the effect size of the addition of variables to the regression models (Cohen, 1988). Effect sizes are reported as per guidance by the American Statistical Association (Wasserstein & Lazar, 2016) and recommendations by various authors (Hayat et al., 2019; Sullivan & Feinn, 2012; Wasserstein & Lazar, 2016). Cohen's f^2 is a standardized measure of the one variable's local effect size in the context of a multivariate regression model (i.e., the unique proportion of the variance accounted for by the variable of interest) (Cohen, 1988; Selya et al., 2012).

3.8 Ethical Considerations

The main study website page that potential participants first encountered (see Appendix B) provided information about the survey and informed consent. Participants had to explicitly acknowledge their provision of informed consent in order to proceed to the survey questions and always had the option to stop the survey at any time or not to complete it (see Section 3.5 and Appendix A for details of informed consent procedures). At the end of the survey, participants were directed away from the Qualtrics™ survey platform to a separate form that was specifically created for collection of email addresses to receive a copy of study results. As survey and email data were held in different locations, it was not possible to link email addresses to survey responses.

Participation in this study posed minimal risks to participants. Participants were asked to respond to perspectives on leadership behaviours in their work area and it is possible that participants may not have felt comfortable speaking to negative aspects of their workplace. One approach taken to mitigate the risk of employers finding out about employee's participation in this survey was emphasizing in the survey instructions for participants not to include any identifying information about themselves and ensuring that survey questions did not ask any identifying information. General questions about respondents' geographic location and work area were asked (city, size of organization, nursing specialty – see Appendix A). However, specific names of units, wards, or organizations were not asked, reducing the likelihood of respondents being linked to an individual organization. Completion of the survey was voluntary; participants were not required to answer any questions they did not want to, in line with ethical norms typically applied to paper surveys (Sue & Ritter, 2011). Furthermore, all respondents were alerted to the option to respond to survey questions with "I don't know," "not applicable," "decline to state," or skip questions altogether (Sue & Ritter, 2011), providing the option not to respond to any questions in the survey that may have been uncomfortable. Finally, only aggregated data are reported. Survey data were only accessible through a password protected personal Qualtrics™ account provided by the University of British Columbia. The Qualtrics ™ account password and any downloaded and locally stored data were only accessible to the research team comprising the researcher and three supervisory committee members. All data that were downloaded for analysis were kept on personal password-protected computers.

3.9 Chapter Summary

In this chapter, details were provided on the study sampling strategy, procedures for data collection, operationalization of study variables, data analysis screening and preparation, data analysis methods, and ethical considerations. A total of sample of 288 Registered Nurses who provided direct patient care and had access to employer-provided mHealth comprised the final sample. The data collection process took place from January to July 2018 and employed best practice guidance for conducting online surveys as outlined in Dillman's TDM and informed by Sue and Ritter's (2011) textbook on conducting online surveys. Existing scales that have been found to be reliable and have demonstrated validity (for use among similar studies with nurses and other health care professionals), were used to measure the key outcome variables, control variables (with the exception of demographic variables), and key predictor variables. The outcome variable intention to use mHealth was measured using questions from TAM3 and the outcome variable actual use of mHealth was measured using Doll and Torkzadeh's tool. The control variables comprised of previous experience with mobile technology, voluntariness (of mHealth use), and nurse demographic characteristics. Voluntariness of mHealth use was measured using a question from TAM3. Previous experience with mobile technology was measured in two ways: the total number of months since mHealth was first used at work and the total number of months since other mobile devices were first used outside of work. The predictor variables perceived usefulness and perceived ease of use were measured using questions from TAM3. The key predictor variable of interest, implementation leadership characteristics, was measured using the Implementation Leadership Scale. At the individual level of analysis, hierarchical multiple regression was used to identify variables associated with intention to use and actual use and the strength of their relationships.

Chapter 4: Results

The study findings are presented in this chapter. Descriptive statistics are reported in the first section which includes demographic characteristics of respondents, practice settings, and specialty areas of practice. The descriptive statistics of key study predictors and outcome variables are reported in the section that follows. Bivariate correlations between the main study variables are reported next. In the final section, findings of the multiple regression analyses with respect to the outcome variables and the results of the moderation analyses are reported.

4.1 Descriptive Statistics of the Sample

In this section, an overview of the demographic and employment characteristics of the sample is described. There were 388 responses to the survey. After removing cases that did not meet inclusion criteria (n=35) or were missing ILS responses (n=65), the final sample consisted of 288 Registered Nurses. The proportion of male respondents in the sample (5.6%, n = 16) which is in line with Canadian registered nurse population of 7.47% (ranging from 4.6% in Prince Edward Island to 11.5% in Quebec), in 2019 (Canadian Institute for Health Information, 2019). Respondents were primarily female (94.4%, n = 272) with a mean age of 41.6 years (SD = 11.9), holding a Bachelor's degree in nursing (67.7%, $n=195$), and have been qualified as a Registered Nurse for an average of 17 years (SD= 12.6, n = 285) (see Table 4.1). With the exception of participants over 60 years of age (8.7%, n = 25), all age groups were split fairly equally. Most respondents were RNs working in large urban settings (57%, n = 163), and primarily in hospital (37%, n = 110) or community health (38.2%, n = 117).

Table 4.1 Participant Demographic Characteristics

Characteristic	Frequency (%) *N* = 288	Mean (*SD*)
Age		41.6 (11.9)
29 years and under	58 (20.1%)	
30 to 39 years	89 (30.9%)	
40 to 49 years	60 (20.8%)	
50 to 59 years	53 (18.4%)	
60 years and above	25 (8.7%)	
Gender		
Female	272 (94.5%)	
Male	16 (5.6%)	
Highest Educational Qualification in Nursing		
RN diploma	64 (22.2%)	
Bachelor of Nursing	195 (67.7%)	
Master of Nursing	21 (7.3%)	
PhD (Nursing)	1 (0.3)	
Other (e.g., advanced practice and specialty diplomas)	7 (2.4%)	
Years since first obtaining RN license		16.9 (12.6)

The majority of responses were from Saskatchewan (44.4%, n = 128), followed by Alberta (21.9%, n = 63). These high response rates are likely reflective of the streamlined and efficient processes to recruit RNs into research studies that were in place in these provinces. A further discussion of the response rates by province can be found in Chapter 5. Organizations captured under the "other" option included private clinics, primary care clinics, nursing stations[4], occupational health, and outreach nursing, among others.

[4] Nursing stations are a healthcare setting where RNs have an expanded scope of practice often providing all aspects of healthcare services including primary health care, public health, and emergency and treatment services, typically located in rural, remote, semi-isolated, and isolated communities (National Joint Council of the Public Service of Canada. (2009). *Unsung Heroes: Health Canada Nurses in Remote and Isolated Communities*.

Table 4.2 Participant Employment Characteristics

Characteristic	Frequency (%) N = 288[c]
Canadian province[a] of employment	
British Columbia	33 (11.5%)
Alberta	63 (21.9%)
Saskatchewan	128 (44.4%)
Manitoba	13 (4.5%)
Ontario	5 (1.7%)
New Brunswick	21 (7.3%)
Newfoundland and Labrador	24 (8.3%)
Type of population setting[b]	
Large urban population centre	163 (56.6%)
Medium population centre	40 (13.9%)
Small population centre	36 (12.5%)
Rural area	48 (16.7%)
Organization type	
Hospital	110 (38.2%)
Community health	117 (40.6%)
Nursing home or other long-term care facility (LTC)	31 (10.8%)
Other	27 (9.4%)

Note. [a] Participant respondents per province do not reflect the distribution of nurses across Canada's ten provinces and three territories. [b]Large urban population centre (>100,000 people; high population density); Medium population centre: (Between 30,000 and 99,999 people; high population density); Small population centre: (Between 1,000 and 29,999 people; high population density); Rural area: All other areas outside of population centres. Extracted from "Population Centre and Rural Area Classification 2016" (Statistics Canada, 2016). [c]The sum of each characteristic do not equal 288 due to missing responses and not reported here, as per conventions of reporting missing data.

While participants were asked to indicated their primary nursing job, they were permitted to provide multiple responses which resulted in 470 total responses (see Table 4.3). Six practice specialties comprised the most commonly reported specialty areas of practice by respondents (70%). In descending order of frequency, respondents practiced in community or public health, medical, geriatrics or care of older people, emergency care, home care, and surgical nursing followed by smaller numbers reported for the remaining practice specialty areas.

Table 4.3 Respondents' Areas of Practice

Practice specialty of primary nursing job[a]	Frequency (%) *N* = 470 specialties for 288 participants
Community or public health	86 (18.3%)
Medical	68 (14.5%)
Geriatrics or care of older people	55 (11.7%)
Emergency care	44 (9.4%)
Home care	39 (8.3%)
Surgical	39 (8.3%)
Critical care	27 (5.7%)
Maternal	21 (4.5%)
End of life	21 (4.5%)
Pediatrics	20 (4.3%)
Psychiatry or mental health	18 (3.8%)
Other	13 (2.8%)
Clinical or health informatics	6 (1.3%)
Occupational health	5 (1.1%)
Primary care[b]	4 (0.9%)
Administration[c]	3 (0.6%)
Correctional	1 (0.2%)

Note. [a]Participants were asked to choose ALL that apply resulting in a total frequency of 470. [b]Primary care was a new category identified in the text responses to "Other, please describe" option. [c]Individuals who indicated 'administration' also selected more than one practice specialty area and indicated their work setting to be in a primary care clinic.

Descriptive statistics of the outcome variables (intention to use and actual use), key predictor variables (implementation leadership characteristics, perceived usefulness, perceived ease of use), and control variables (voluntariness, previous experience with work mHealth and non-work mobile) are reported in Table 4.4. Histograms for the variables perceived usefulness, perceived ease of use, previous experience with work mHealth, and voluntariness were skewed therefore medians are reported for these variables; unlike means, medians are less sensitive to skewed distributions (Field, 2009).

Overall, scores for the outcome variables indicated relatively high intention to use mHealth and moderately high actual use of mHealth among respondents (see Table 4.4). For key predictor variables, respondent scores indicated moderate perceptions of implementation leadership characteristics related to mHealth implementation. The median scores for the known predictors perceived usefulness and perceived ease of use suggested that respondents moderately perceived mHealth use at work to be useful and easy to use. There was a median of 48.95 months (4.08 years) of experience with work mHealth and an average of 162.48 months (13.54 years) of experience with non-work mobile technology use. The median score for voluntariness suggested that nurses did not tend to perceive the use of mHealth in their work as voluntary.

Table 4.4 Description of Model Variables

Characteristic	Mean (SD)	Median	Range
Outcome variables			
Intention to use	6.01 (1.13)		2-7
Actual use	37.57 (12.66)		14-70
Key predictor variables			
Implementation leadership characteristics	2.13 (1.05)		0-4
Perceived Usefulness		6.00	1-7
Perceived Ease of Use		5.25	1-7
Control variables[a]			
Previous experience with work mHealth (in months)		48.95	0.36-339.34
Previous experience with non-work mobile (in months)	162.48 (79.63)		0.36-342.46
Voluntariness		2.33	1-7

Note. N=288. [a] The control variables age, gender, and education were described in Table 4.1.

4.2 Bivariate Correlations

To assess the strength of relationships between major study variables, bivariate correlations were computed using Pearson's r, point-biserial correlations (r_{pb}), and phi (φ) correlation analyses (see Table 4.5). These correlation statistics also provide insight into the contribution of different variables and inform the interpretation of the main regression analyses results (Field, 2009). Considering the guidance on interpreting magnitudes of correlations by both Cohen and Hemphill, none of the bivariate correlations among the independent variables are deemed highly correlated (i.e., all are $r < .8$) (Cohen, 1988; Field, 2009; Hemphill, 2003).

Table 4.5 Bivariate Correlation Matrix of Study Variables

Variable	1	2	3[a]	4[a]	5	6	7	8	9	10
1. Intention to use	-									
2. Actual use	**.35****	-								
3. Gender [a]	.02	-.06	-							
4. Education [a]	-.02	-.02	.03[b]	-						
5. Age	-.05	-.06	.11	**.13***	-					
6. Previous experience - mHealth at work	-.08	-.07	.02	-.03	**.42****	-				
7. Previous experience – non-work mobile	.01	-.03	.09	.04	**.26****	**.26****	-			
8. Voluntariness	**-.17****	**-.30****	**-.17****	**.13***	**-.26****	-.07	**-.16***	-		
9. Perceived usefulness	**.58****	**.45****	-.10	-.06	-.10	-.07	-.05	-.03	-	
10. Perceived ease of use	**.51****	**.20****	-.02	-.02	**-.20****	**-.14***	.004	.04	**.56****	-
11. Implementation leadership characteristics	**.27****	**.41****	.01	**-.16****	**.17****	.02	**.13***	**-.50****	**.32****	**.26****

$*p < .05$. $**p < .01$. $***p < .001$.
Note. Gender (0= male, 1= female), Education (0 = RN diploma or Bachelor of Nursing Degree, 1= Nursing Graduate Degree or Other). [a]*Point biserial correlations (r_{pb}) were computed for gender and education in relation to all variables except each other.* [b]*Phi (φ) was computed for the relationship between gender and education. Pearson's correlations (r) were computed for all other bivariate relationships.*

The correlation between the two outcome variables intention to use and actual use are positive and moderate to large (*r=.34, p <.01*), suggesting that while these outcome variables are correlated, they are not measuring the same concept. A small negative relationship was found between intention to use and voluntariness *(r=-.17, p <.01)* suggesting that greater perceptions of voluntariness were associated with decreased intention to use mHealth. Correlations between intention to use and the key predictors perceived usefulness (*r=.59, p <.01)* and perceived ease of use (*r=.51, p <.01)* were large and positive suggesting that greater perceptions of perceived usefulness and perceived ease of use were correlated with greater intention to use mHealth. A moderate positive relationship was found between intention to use and the key predictor implementation leadership (*r=.27, p <.01)*, which suggests that stronger implementation leadership was significantly associated with greater intention to use mHealth.

With the outcome variable actual use, a small to moderate negative relationship was found with voluntariness (*r= -.30, p <.01*), suggesting that those who perceived mHealth use to be voluntary used mHealth less. Actual use had a moderate to large positive association with the key predictor perceived usefulness *(r=.45, p <.01)* and a moderate positive association with perceived ease of use *(r=.20, p <.01)*, suggesting the greater perceptions of mHealth as useful and easy to use were linked to an increased use of mHealth. The positive moderate to large correlation between actual use and the key predictor implementation leadership *(r=.41, p <.01)* was found as expected; higher implementation leadership is associated with greater actual use of mHealth.

Among control variables, education was found to have a small positive relationship with age *(φ =.13, p <.01)* and voluntariness *(r_{pb} =.13, p <.01)*, suggesting that the highest level of education corresponded with older age as well as greater perceptions of mHealth use being voluntary, respectively. A small negative relationship was found between education and implementation leadership *(r_{pb} =-.61, p <.01)*, suggesting that higher levels of education were associated with perceptions of lower implementation leadership. A moderate to large positive relationship was found between age and previous experience with work mHealth *(r=.42, p <.01)*, suggesting that older age was associated with greater experience with using mHealth at work. Significant small to medium positive associations were found between age and previous experience with non-work mobile *(r=.26, p <.01)* and implementation leadership characteristics *(r=.17, p <.01)*, suggesting that older participants had more experience in using mobile technologies outside of work and perceived implementation leadership to be greater, respectively. Small to moderate negative relationships were found between age and voluntariness *(r=-.26, p <.01)* and perceived usefulness *(r=-.20, p <.01)*, suggesting that older participants perceived the use of mHealth at work to be less voluntary and useful, respectively.

A positive moderate relationship was found between previous experience with work mHealth and previous experience with non-work mobile use *(r=.26, p <.01)*, suggesting that those with more experience using work mHealth also had more experience with using mobile technologies outside of work. A small negative relationship was found between previous experience with work mHealth and perceived ease of use *(r=-.14, p <.01)*, suggesting that participants who had more experience using mHealth at work also perceived these to be less easy to use. Previous experience with non-work mobile technologies was associated with a small negative relationship with voluntariness *(r=-.16, p <.01)*, suggesting that those with greater experience using mobile technologies outside of work perceived the use of these technologies to be less voluntary. As well, previous experience with non-work mobile technologies was associated with a small positive relationship with implementation leadership *(r=.13, p <.01)*, suggesting that greater experience with non-work mobile technologies was associated with greater perceptions of implementation leadership characteristics of those responsible for implementing mHealth. Voluntariness had a large negative relationship with implementation leadership characteristics *(r=-.50, p <.01)*, suggesting that greater perceptions of implementation leadership were associated with lower perceptions of mHealth use being voluntary.

Among key predictors, perceived usefulness was found to have a large positive relationship with perceived ease of use *(r=.56, p <.01)*. This relationship suggests that those who found mHealth useful also largely found it easy to use. Perceived usefulness was found to have a moderate positive relationship with implementation leadership characteristics *(r=.32, p <.01),* suggesting that those who found mHealth useful also moderately perceived greater implementation leadership. Finally, perceived ease of use was found to have a moderate positive relationship with implementation leadership *(r=.26, p <.01),* suggesting that those who found mHealth easy to use also moderately perceived greater implementation leadership.

4.3 Hierarchical Multiple Regression Findings

This section reports on findings of the multiple regression analyses with respect to each of the two outcome variables: intention to use mHealth and actual use of mHealth. In the subsections that follow, the detailed reporting of the multiple regression analyses for each of the outcome variables are described. In the last subsection, the summary of the results of the multiple regression analyses models for intention to use and actual use are outlined.

Examining the residual scatterplots for models with the dependent variable *actual use* suggested the presence of possible heteroscedasticity. Limitations of using graphical approaches to explore models assumptions were noted and recognized that "residual plots may provide one piece of the puzzle to assess heteroskedasticity but cannot be exhaustive" (Astivia & Zumbo, 2019, p. 5). As recommended by Astivia and Zumbo (2019), a further assessment of heteroscedasticity was conducted via the Breusch-Pagan test which examines whether the model errors are associated with any of the model predictors (Breusch & Pagan, 1979). The results of the Breusch-Pagan test suggested no evidence of heteroskedasticity for all actual use models. As such, no transformations were required. Based on the results of the completed diagnostics, assumptions to perform regression analyses were met (Field, 2009).

4.3.1 Intention to Use mHealth

Regression results for the five final models predicting intention to use mHealth are reported in Table 4.6. Model 4 shows that implementation leadership characteristics were not found to have a significant influence on intention to use mHealth over and above control variables (nurses' demographic characteristics, previous experience with mHealth, voluntariness) and other known predictors (perceived usefulness and perceived ease of use). Model 5, which included the interaction term implementation leadership*education, explained 47% of the variance in nurses' intention to use mHealth in their clinical practice (F (10, 228) = 20.14, p <.001). The effect size attributable to the addition of implementation leadership characteristics to Model 4 is Cohen's f^2 = 0.01 and the effect size attributable to the addition of the implementation leadership*education interaction term to Model 5 is Cohen's f^2 = 0.02; both are considered small effect sizes (Cohen, 1992).

The strongest predictors of nurses' intention to use mHealth were determined by looking at the squared semipartial correlations. In hierarchical multiple regression analyses, squared semipartial correlations (sr_i^2) are indicated by the R^2 change in the model summary, after the point of entry of the variable of interest in the model, and sum to R^2 (Tabachnick & Fidell, 2013). In the intention to use mHealth models, perceived usefulness (β = .44, p <.001) and perceived ease of use (β = .35, p <.001) were found to be the strongest predictor of nurses' intention to use mHealth (sr_i^2 = 0.41). The positive beta coefficients suggest that one standard deviation increase in perceptions that mHealth was useful and easy to use was associated with an increase in nurses' intention to use mHealth by .44 and .35 standard deviations, respectively. The addition of perceived usefulness and perceived ease of use accounted for 41% of the R^2 and the addition of other variables did not change the beta coefficients for these variables substantially. A small to moderate effect size (Cohen's $f^2 = 0.13$) can be attributed to the addition of perceived usefulness and perceived ease of use (Cohen, 1992).

With regard to the third research question, voluntariness was not found to moderate the relationship between implementation leadership characteristics and intention to use. Voluntariness ($\beta = -.21$, $p < .001$) was found to be negatively associated with nurses' intention to use mHealth in the final model, with no substantial change after the addition of other variables. This negative beta coefficient suggests that one standard deviation increase in perceptions that mHealth use was voluntary (i.e., not mandatory) was associated with a decrease in nurses' intention to use mHealth by .21. In other words, if nurses had the option (i.e., it was voluntary) whether or not to use mHealth in their work, they had lower intention to use mHealth.

With regard to the six interaction terms that were tested, only the interaction term for implementation leadership*education (Aiken et al., 1991) was statistically significant in the final model ($\beta = -.21$, $p < .05$) and negatively associated with nurses' intention to use mHealth. This significant negative beta coefficient and the plotted interaction in Figure 4.3 suggests that education moderated the effect of implementation leadership characteristics on nurses' intention to use mHealth. The interaction plot in Figure 4.3 depicts simple regression lines that plot implementation leadership characteristics with intention to use mHealth for each education group. The figure suggests that perceptions of higher implementation leadership had a greater influence on the intention to use mHealth among nurses with an RN diploma or Bachelor of Nursing Degree compared to nurses with a Graduate or Other degree. This is seen by the steeper slope for the regression line for nurses with an RN diploma or Bachelor of Nursing Degree. Moreover, lower levels of implementation leadership among nurses with graduate degrees were associated with higher intention to use mHealth, compared with nurses with diploma and bachelor of nursing degrees. At higher levels of implementation leadership however, nurses with an RN diploma or Bachelor of Nursing Degree showed higher levels of intention to use mHealth compared with nurses with a Graduate or Other degree, not controlling for other variables. The inclusion of the interaction term in the final model does not allow for the interpretation of the primary effects of implementation leadership on intention to use mHealth (Tabachnick & Fidell, 2013).

Table 4.6 Final Regression Model Predicting Intention to Use mHealth

	B	*SE* B	*β*	CI (95%)		R^2	ΔR^2
				Lower	Upper		
Model 1						.004	.004
Gender	-0.10	0.32	-0.02	-0.73	0.53		
Education	-0.12	0.26	-0.03	-0.62	0.39		
Age	-0.00	0.01	-0.01	-0.02	0.01		
Months of previous experience (work mHealth)	-0.01	0.02	-0.05	-0.04	0.02		
Months of previous experience (non-work mobile)	0.00	0.01	0.02	-0.02	0.03		
Model 2						.04	.03
Gender	-0.22	0.32	-0.05	-0.85	0.410		
Education	0.01	0.26	0.00	-0.50	0.512		
Age	-0.01	0.01	-0.06	-0.02	0.009		
Months of previous experience (work mHealth)	-0.01	0.02	-0.03	-0.04	0.023		
Months of previous experience (non-work mobile)	0.00	0.01	-0.00	-0.02	0.023		
Voluntariness	-0.11	0.04	**-0.20****	-0.18	-0.033		
Model 3						.45	.41
Gender	0.10	0.25	0.02	-0.38	0.59		
Education	0.15	0.19	0.04	-0.23	0.54		
Age	0.00	0.01	0.01	-0.01	0.01		
Months of previous experience (work mHealth)	-0.01	0.01	-0.03	-0.03	0.02		
Months of previous experience (non-work mobile)	0.00	0.01	0.00	-0.02	0.02		
Voluntariness	-0.09	0.03	**-0.17****	-0.15	-0.04		
Perceived usefulness	0.36	0.05	**0.42*****	0.26	0.45		
Perceived ease of use	0.29	0.05	**0.33*****	0.19	0.39		

Table 4.6 Final Regression Model Predicting Intention to Use mHealth (cont.)

	B	*SE* B	β	CI (95%)		R^2	ΔR^2
				Lower	**Upper**		
Model 4						.46	.006
Gender	0.07	0.25	0.02	-0.41	0.55		
Education	0.11	0.20	0.03	-0.27	0.50		
Age	0.00	0.01	0.02	-0.01	0.01		
Months of previous experience (work mHealth)	-0.01	0.01	-0.03	-0.03	0.02		
Months of previous experience (non-work mobile)	0.00	0.01	0.01	-0.02	0.02		
Voluntariness	-0.11	0.03	**-0.21*** **	-0.18	-0.05		
Perceived usefulness	0.37	0.05	**0.44*** **	0.27	0.47		
Perceived ease of use	0.30	0.05	**0.35*** **	0.20	0.41		
Implementation leadership characteristics	-0.11	0.07	-0.10	-0.24	0.03		
Model 5						.47	.012
Gender	0.07	0.25	0.02	-0.41	0.55		
Education	0.11	0.20	0.03	-0.27	0.50		
Age	0.00	0.01	0.02	-0.01	0.01		
Months of previous experience (work mHealth)	-0.01	0.01	-0.03	-0.03	0.02		
Months of previous experience (non-work mobile)	0.00	0.01	0.01	-0.02	0.02		
Voluntariness	-0.11	0.03	**-0.21*** **	-0.18	-0.05		
Perceived usefulness	0.37	0.05	**0.44*** **	0.27	0.47		
Perceived ease of use	0.30	0.05	**0.35*** **	0.20	0.41		
Implementation leadership characteristics	-0.11	0.07	-0.10	-0.24	0.03		
Implementation leadership*education	-0.43	0.19	**-0.21* **	-.81	-.05		

*$p < .05$, **$p < .01$, ***$p < .001$
Note. n=238. Model 5: F (10,228) = 20.14, p <.001
Gender (0= male, 1= female), Education 0= RN diploma or Bachelor of Nursing Degree, 1= Nursing Graduate Degree or Other).

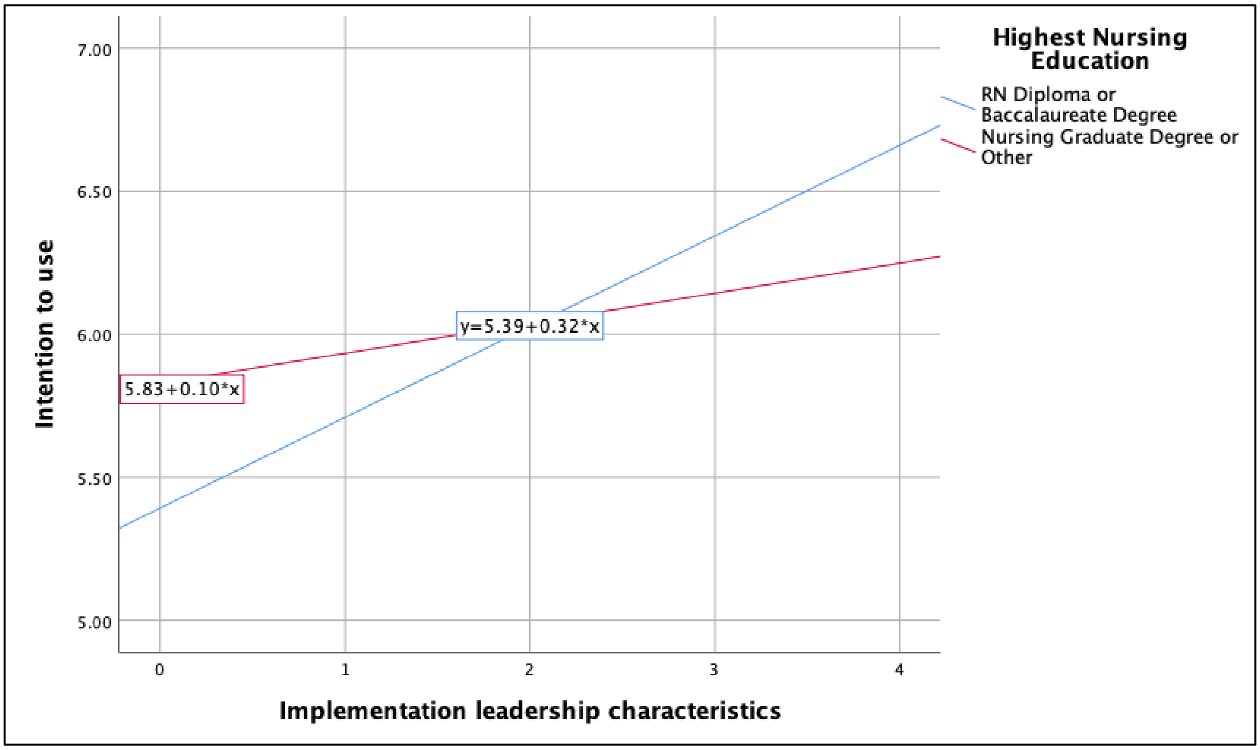

Figure 4.1 The moderating effect of education on the relationship between implementation leadership characteristics and nurses' intention to use mHealth

4.3.2 Actual Use of mHealth

Results for the five regression models predicting actual use of mHealth are presented in Table 4.7. Implementation leadership characteristics were found to have a significant influence on actual use of mHealth over and above control variables (nurses' demographic characteristics, previous experience with mHealth, voluntariness) and other known predictors (perceived usefulness and perceived ease of use) in models 4 (β = .22, p <.01) and 5 (β = .63, p <.01). The final model explained 40% of the variance in nurses' actual use of mHealth in their work (F (10, 228) = 15.18, p <.001). Cohen's f^2 = 0.20 was obtained which represents a medium effect size attributable to the addition of the implementation leadership*age interaction term (Cohen, 1992).

In model 2, gender was statistically significant (β = -.15, p <.05) along with voluntariness of mHealth use (β = .38, p <.001). Voluntariness remained statistically significant in model 3 (β =-.35, p <.001), model 4 (β = -.25, p <.001), and model 5 (β = -.26, p <.001). The negative beta coefficient for voluntariness suggests that one standard deviation increase in perceptions of voluntariness was associated with decreases in nurses' actual use of mHealth by .26 standard deviations in the final model.

With regard to the third research question, voluntariness was not found to moderate the relationship between implementation leadership characteristics and actual use (interaction variable not shown). The addition of the key predictor perceived usefulness was statistically significant in model 3 (β = .49, p <.001) and its addition to the model (along with perceived ease of use) had a moderate effect size (Cohen's f^2 = 0.33). Perceived usefulness was also significant in model 4 (β = .45, p <.001), and model 5 (β = .47, p <.001). Perceived usefulness was the strongest predictors of nurses' actual use of mHealth (sr_i^2 = 0.21) in model 3. The positive beta coefficients for perceived usefulness suggests that one standard deviation increase in perceptions that mHealth was useful was associated with an increase in nurses' actual use of mHealth .47 standard deviations, in the final model.

Table 4.7 Final Regression Model Predicting Actual Use of mHealth

	B	***SE* B**	***β***	**CI (95%)**		**R^2**	**ΔR^2**
				Lower	**Upper**		
Model 1						.02	.02
Gender	-0.38	0.25	-0.10	-0.87	0.12		
Education	-0.05	0.20	-0.02	-0.45	0.34		
Age	-0.00	0.01	0.00	-0.01	0.01		
Months of previous experience (work mHealth)	-0.01	0.01	-0.07	-0.04	0.01		
Months of previous experience (non-work mobile)	-0.00	0.01	-0.01	-0.02	0.02		
Model 2						.15	.13
Gender	-0.56	0.24	**-0.15***	-1.03	-0.10		
Education	0.14	0.19	0.05	-0.23	0.51		
Age	-0.01	0.01	-0.10	-0.02	0.00		
Months of previous experience (work mHealth)	-0.01	0.01	-0.05	-0.03	0.01		
Months of previous experience (non-work mobile)	-0.01	0.01	-0.05	-0.02	0.011		
Voluntariness	-0.16	0.03	**-0.38*****	-0.21	-0.11		
Model 3						.36	.21
Gender	-0.31	0.21	-0.08	-0.72	0.10		
Education	0.22	0.16	0.072	-0.11	0.54		
Age	-0.01	0.01	-0.10	-0.02	0.00		
Months of previous experience (work mHealth)	-0.01	0.01	-0.05	-0.03	0.01		
Months of previous experience (non-work mobile)	-0.00	0.01	-0.03	-0.02	0.01		
Voluntariness	-0.15	0.02	**-0.35*****	-0.19	-0.10		
Perceived usefulness	0.32	0.04	**0.49*****	0.24	0.40		
Perceived ease of use	-0.03	0.04	-0.05	-0.12	0.05		

Table 4.7 Final Regression Model Predicting Actual Use of mHealth (cont.)

	B	*SE* B	*β*	CI (95%)		R^2	ΔR^2
				Lower	Upper		
Model 4						.39	.03
Gender	-0.26	0.20	-0.07	-0.66	0.14		
Education	0.29	0.16	0.10	-0.03	0.61		
Age	-0.01	0.01	-0.13	-0.02	0.00		
Months of previous experience (work mHealth)	-0.01	0.01	-0.04	-0.03	0.01		
Months of previous experience (non-work mobile)	-0.01	0.01	-0.04	-0.02	0.01		
Voluntariness	-0.11	0.03	**-0.25*** **	-0.16	-0.05		
Perceived usefulness	0.30	0.04	**0.45*** **	0.21	0.38		
Perceived ease of use	-0.06	0.04	-0.09	-0.15	0.02		
Implementation leadership characteristics	0.19	0.06	**0.22** **	0.08	0.30		
Model 5						.40	.01
Gender	-0.26	0.20	-0.07	-0.66	0.14		
Education	0.28	0.16	0.09	-0.04	0.59		
Age	-0.01	0.01	-0.11	-0.01	0.03		
Months of previous experience (work mHealth)	-0.00	0.00	-0.04	-0.03	0.01		
Months of previous experience (non-work mobile)	-0.00	0.00	-0.05	-0.02	0.01		
Voluntariness	-0.11	0.03	**-0.26*** **	-0.16	-0.06		
Perceived usefulness	0.31	0.04	**0.47*** **	0.23	0.39		
Perceived ease of use	-0.07	0.04	-0.10	-0.15	0.02		
Implementation leadership characteristics	0.54	0.17	**0.63** **	0.20	0.88		
Implementation leadership*age	-0.01	0.00	**-0.53* **	-0.02	-0.001		

*p < .05, **p < .01, ***p < .001
Note. n=238. Model 5: F (10,228) = 15.18, p <.001
Gender (0= male, 1= female), Education 0= RN diploma or Bachelor of Nursing Degree, 1= Nursing Graduate Degree or Other).

Regarding the interactions between implementation leadership characteristics and the six nurses' demographic characteristics that were tested, only the interaction term for implementation leadership*age was found to be statistically significant (β = -.53, p <.05). The interaction term implementation leadership*age had the second largest beta coefficient in the final model. This significant negative beta coefficient and the plotted interaction in Figure 4.4 suggests that age moderates the effect of implementation leadership on nurses' actual use of mHealth, with implementation leadership having a greater influence on the three youngest groups: nurses 29 years old and younger ($r=.49$, $p<.001$), 30 to 39 years old ($r=.50$, $p<.001$), and 40 to 49 years old ($r=.44$, $p<.001$). These younger age groups showed large correlations between implementation leadership and actual use of mHealth. In contrast, nurses in the older age groups had smaller correlations between implementation leadership and actual use, which includes those 50 to 59 years old ($r=.34$, $p<.01$) and 60 years old and above had a small and non-significant correlation ($r=.23$, $p>.05$). A potential explanation of the non-significant effect of implementation leadership characteristics on actual use for nurses 60 years old and above is the smaller subsample of this group, increasing the likelihood of a Type 2 error.

Voluntariness was a significant negative predictor of both intention to use and actual use of mHealth, as found elsewhere (Venkatesh & Davis, 2000) and among other healthcare professionals (Kifle et al., 2010), although voluntariness of use was not found to moderate the relationships between implementation leadership characteristics and nurses' intention to use and actual use of mHealth, as proposed in research question 3.

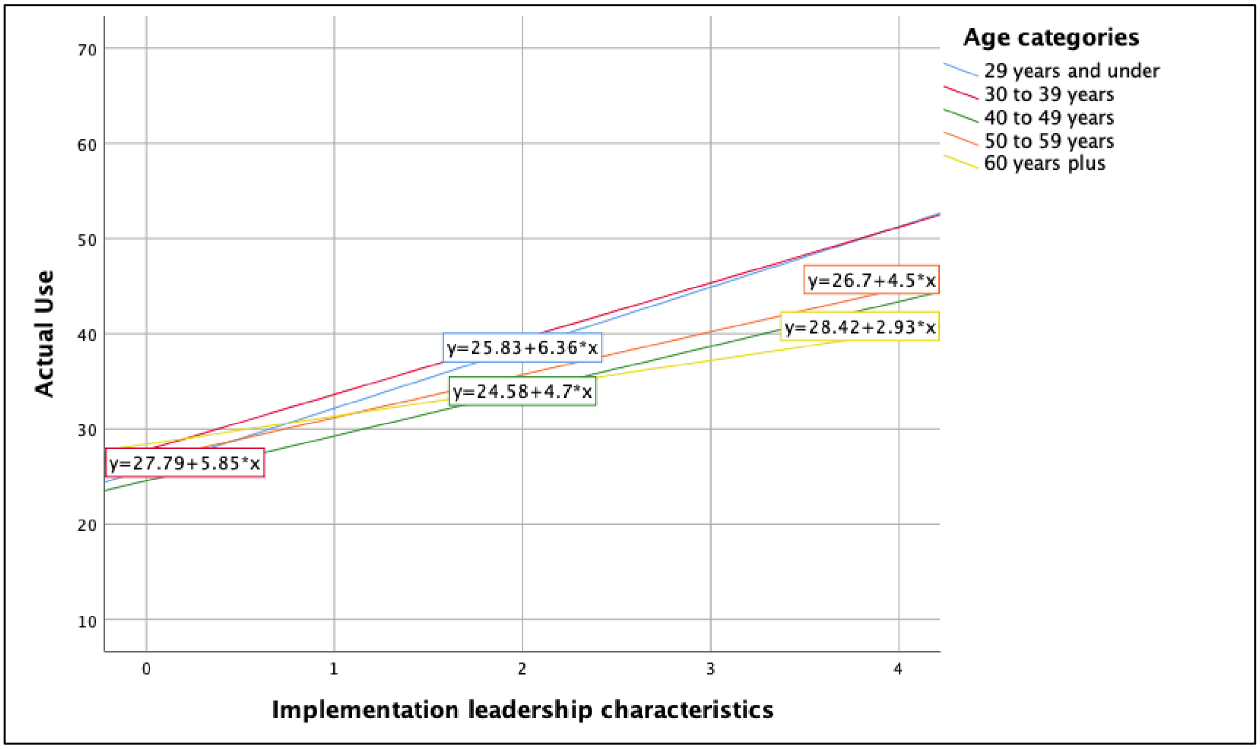

Figure 4.2 The moderating effect of age on the relationship between implementation leadership characteristics and nurses' actual use of mHealth

4.4 Chapter Summary

Implementation leadership characteristics were not found to have a significant primary effect on nurses' intention to use mHealth after controlling perceived usefulness, perceived ease of use (known key predictors), voluntariness of mHealth use (control variable), nurses' demographic characteristics and previous experience with mHealth and other mobile technologies (control variables). However, the implementation leadership*education interaction term was found to have a significant influence on nurses' intention to use mHealth. More specifically, it was found that there was a greater influence of implementation leadership on the intention to use mHealth among nurses with an RN diploma or Bachelor of Nursing degree compared to those with Graduate or other degrees.

With regard to nurses' actual use of mHealth, the implementation leadership*age interaction term was found to significantly influence nurses' actual use of mHealth after controlling for known key predictors and characteristics of nurses. The effect of implementation leadership characteristics was found to vary by age, where higher perceptions of implementation leadership were associated with higher assessments of actual use of mHealth for younger nurses. These results suggest that implementation leadership characteristics of first-level leaders have a role in influencing nurses' intention to use and actual use of mHealth and these effects are moderated by education level and age, respectively. Finally, voluntariness was not found to moderate the relationship implementation leadership characteristics and nurses' intention to use mHealth nor actual use of mHealth. This means that no significant interactions were found between voluntariness with the effects of implementation leadership characteristics, with respect to nurses' use of mHealth in their work. A detailed discussion of these results in the context of the literature will be presented in the next chapter.

Chapter 5: Discussion

This was a cross-sectional, exploratory correlational study that was conducted to examine the effects of implementation leadership characteristics of first-level leaders, technology characteristics, and nurses' individual characteristics, with respect to nurses' intention to use and actual use of mHealth in their clinical practice. Hierarchical multiple regression analyses were used to test the proposed relationships between predictors of mHealth use, implementation leadership characteristics, and nurses' use of mHealth in clinical practice. To date, no other studies could be identified that have examined the role of leadership in relation to the intention to use and actual use of mHealth in nursing, highlighting the novelty of this study. The focus on mHealth however, reflects recent trends in studies that have used TAM or its adaptation or extension as a framework to understand mobile technology use (Rahimi et al., 2018).

In the first two sections of this chapter, the key findings with respect to implementation leadership characteristics are discussed, followed by a discussion of the key findings with respect to perceived usefulness, perceived ease of use, and voluntariness, all in relation to nurses' intention to use and actual use of mHealth. These key findings are interpreted in relation to the current state of the literature. The subsequent section addresses study limitations and discusses the implications of these limitations on the interpretability and generalizability of results. In the last section of this chapter, contributions to theory, implications for nursing leadership, and future research directions are discussed.

5.1 Key findings

There were several key findings with respect to intention to use and actual use of mHealth among nurses. Higher perceptions of implementation leadership characteristics were associated with greater intention to use mHealth among nurses, with greater influence of implementation leadership among nurses who held RN diplomas or Bachelor of Nursing Degrees as compared to nurses who held Graduate degrees or other advanced education. Implementation leadership also influenced nurses' actual use of mHealth, with implementation leadership characteristics having a greater effect on nurses aged 29 to 49 years as compared to nurses aged 50 years and older. Greater perceptions of the usefulness of mHealth was associated with greater intention to use and actual use of mHealth by nurses. These findings will be interpreted and discussed in the context of the literature in the following sections.

5.1.1 The Effects of Implementation Leadership on Intention to Use mHealth

Education had a significant moderating effect on the relationship between implementation leadership characteristics and nurses' intention to use mHealth. This result suggests that implementation leadership characteristics were more influential in predicting nurses' intention to use mHealth among nurses with RN diploma or Bachelor of Nursing Degree as compared to nurses with a Nursing Graduate Degree or other advanced education. A possible explanation is the potential difference in type of roles and subsequent levels of autonomy among individuals in each of these groups. For example, nurses who hold graduate degrees and other advanced practice diplomas may be more likely to hold roles with greater autonomy in clinical practice (i.e., greater autonomy in their provision of direct patient care) (Wynd, 2003), thus attenuating the effects of implementation leadership on their use of mHealth.

Although the moderating effect size was small suggesting limited practical implication of this finding, it remains worth considering that varied implementation leadership behaviours may be needed to support the different sub-groups of nurses rather than taking a "one size fits all" approach to mHealth implementation, particularly when dealing with diverse groups of nurses. Moreover, further analyses of the relationships between the dimensions of implementation leadership with level of education – while beyond the scope of this study – may reveal additional details of the nature and magnitude of relationships which can better guide practical considerations for implementation leadership practices and other interventions aimed at increasing nurses' intention to use mHealth.

Although this study focused on implementation leadership as a variable of interest, the findings have some parallels with studies that have investigated the moderating role of education on the effects of social influence and facilitating conditions on intention to use technologies. The concepts of social influence and facilitating conditions relate to the influence of social pressures and perceptions of available knowledge and resources that support technology use; these indirectly and implicitly subsume the effects of implementation leadership. A study by Ibrahim et al. (2019) found no significant moderating effects of level of education on the relationships between social influence or facilitating conditions with nurses' intention to use an electronic documentation system. Similarly, Owusu-Kwateng et al. (2019) did not find education to have a significant moderating effect on the effect of either social influence or facilitating conditions on healthcare professionals' intention to use a health information system. Although the results from these studies are not directly comparable to the findings in this dissertation research, these contrasting results on the potential effect of level of education on nurses' intention to use HIT provide insight into the continued challenge of understanding mHealth and HIT use among nurses where there has yet to be consistency and common approaches in the models and measurements used to understand technology use. Comparing the measurement items for social influence and facilitating conditions (UTAUT measures) with the measurement items for implementation leadership (ILS) suggests an overlap between concepts at a high level, where aspects of implementation leadership characteristics are captured in five out of the eight items for social influence and facilitating conditions. Despite these overlaps in coverage, it is possible that the ways that nurses are oriented by questions in the instruments used (i.e., focusing on perceptions of self, versus perceptions of leadership) may play a role in the contradictory findings related to the effect of education on implementation leadership as compared to effects on social influence and facilitating conditions. Moreover, the greater range of dimensions captured by the ILS may make this tool better suited to capture implementation leadership behaviours in the context of nursing practice, whereas the UTAUT measures for social influence and facilitating conditions may address only limited aspects of leadership.

5.1.2 The Effects of Implementation Leadership on Actual Use of mHealth

Age was found to moderate the effects of implementation leadership on nurses' actual use of mHealth. Specifically, it was found that implementation leadership had a greater influence on increasing actual use of mHealth among younger nurses as compared to older nurses.

There are several potential explanations for the moderating effect of age on actual mHealth use. One possible explanation may relate to the degree of expertise and self-efficacy that develop with increasing age and experience (Benner et al., 2009; Bobay et al., 2009; Welch & Carter, 2020). It is possible that older nurses are more likely to have established ways of learning and acculturating to changes in their own practice, and so, they are less influenced by the implementation leadership behaviours of first-level leaders who are promoting the use of mHealth. Venkatesh et al. (2012) suggest that facilitating conditions relate to broader support and infrastructure issues which is in line with my previous discussion of the potential overlap between facilitating conditions and implementation leadership. Considering this, another potential explanation for the greater influence of implementation leadership among younger nurses may be that implementation leadership behaviours of first-level leaders are insufficient to mitigate the barriers that older nurses face in using mHealth in practice. Effectively, this may temper the effect of implementation leadership on older nurses. Considering the findings in several studies where older nurses were found to be more reluctant, less comfortable, and less likely to use HIT (Kummer et al., 2013; Singh & Senthil, 2015; Whittaker et al., 2011); it is possible that there is a perception among older nurses that first-level leaders responsible for facilitating mHealth use among nurses are unable to help them. Another potential explanation relates to one of the initial queries posed in this study relating to the sufficiency of existing technology acceptance models for capturing the unique contexts of nursing practice. Indeed, Venkatesh et al. (2012) highlighted that future work related to UTAUT "can examine other key constructs that are salient to different research contexts when building the models," (pp. 171-172). Finally, differences in the measurement of actual use may account for the contradictory findings in this study in comparison to the study by Venkatesh et al. (2012). Whilst Venkatesh

(2012) used variety and frequency as a measure of actual use, Doll and Torkzadeh's (1998) measure of actual use employed in this study differs in that it captures actual use as a multidimensional concept. Arguably, a multidimensional view of actual use can provide a more nuanced understanding of use behaviours, as the instrument elicits feedback about the nature and purpose of use. The use of Doll and Torkzadeh's measure of actual use brings the focus into technology use from the perspective of providing value; Shachak et al. (2019) suggest that viewing use in the context of the value that it adds allows for the linking of use behaviours to specific tasks. In comparison, measuring the frequency and type of use provides limited information and limits interpretability of results; the question remains as to whether a high frequency of use translates to meaningful use or perhaps reflects challenges in use which results in a greater amount of time spent using the technology.

Overall, the number of potential explanations for the moderating effect of age on implementation leadership span a broad range of possibilities which suggests that there remains a lack of clarity and underdevelopment related to the understanding of the role of age in influencing nurses' actual use of mHealth in practice. Similar to the study by Guo et al. (2016) that found seemingly contradictory effects of personalization and privacy in influencing the use of technologies that varied by age groups, it is likely that there are additional factors influencing the interaction between implementation leadership and age, and the subsequent effect on actual use that warrant further exploration.

Research in the realm of implementation leadership is moving beyond studying the presence or absence of leadership to studying which specific leadership behaviours are most important. A recent review of the concept of implementation leadership characteristics suggests that the concept continues to evolve, but nevertheless holds potential promise for use in the context of nursing (Castiglione, 2019). Along the same lines, a systematic review conducted by Gifford et al. (2018) focused on managerial leadership and sought to identify leadership behaviours that were associated with supporting research use among nurses. Findings from the review identified a range of leadership behaviours that included being change-oriented, task-oriented, relation-oriented, and supportive and demonstrating commitment to research-based practices – behaviours that hold parallels with the dimensions of implementation leadership. Results from this study provide support for the attenuated effects of implementation leadership on both intention to use and actual use of mHealth in nursing and contribute to the body of work that aims to better understand and delineate what effective leadership behaviours to support mHealth use in nursing might look like.

5.2 The Effects of Perceived Usefulness and Perceived Ease of Use

Perceived usefulness was found to be the strongest predictor of both nurses' intention to use and actual use of mHealth to support direct patient care. For intention to use, perceived ease of use was additionally found to be a significant predictor.

The significant effects of perceived usefulness and perceived ease of use on nurses' intention to use mHealth were expected and werenin line with results that have been found elsewhere (Ho et al., 2019; Holden et al., 2016a; Mardiana et al., 2015; Venkatesh & Davis, 2000), with perceived usefulness being the strongest predictor of intention to use (Tubaishat, 2018; Venkatesh & Bala, 2008). The large effect size for the addition of perceived usefulness and perceived ease of use suggests that these variables are of practical importance in influencing nurses' intention to use mHealth in their practice (Griffiths & Needleman, 2019). These findings concur with those in the systematic review by (Gagnon et al., 2016) that found a similar significant importance of these variables on mHealth use, particularly of perceived usefulness. As such, these results provide support for the importance of evaluating nurses' assessments of the potential contributions and impacts to nurses' provision of direct patient care and workflows of any potential mHealth technologies by organizations prior to their deployment. Indeed, this provides further support for the need to involve nurses in early and/or all stages of the system life cycle (Lavin et al., 2015) and the importance of person-centered design (Al-Masslawi, 2015; Al-Masslawi et al., 2017; Tang et al., 2018). The moderate effect size of the addition of perceived usefulness provided support for the importance of assessing nurses' perceptions of perceived usefulness as a necessary part of mHealth planning and implementation, reflecting findings of the importance of this variable in shaping the actual use of these technologies in other studies (Gagnon et al., 2016).

It was notable that perceived ease of use was a significant predictor of nurses' intention to use mHealth but not a significant predictor of nurses' actual use of mHealth. These findings reflect similar results from a study by Maillet et al. (2015) which examined nurses' use of electronic patient records. In their study, Maillet and colleagues (2015) found perceived usefulness (captured by the concept of performance expectancy (Holden & Karsh, 2010)) to have a positive and significant influence whilst perceived ease of use (captured by the concept of effort expectancy (Holden & Karsh, 2010)) did not to have a significant influence on nurses' actual use of electronic patient records. They also found that the link between perceived ease of use and facilitating conditions (which captures some aspects of implementation leadership characteristics) were among the strongest relationships identified (Maillet, 2014; Maillet et al., 2015).

5.3 Voluntariness Does Not Moderate ILS

Voluntariness was not found to moderate the effect of implementation leadership characteristics on either intention to use, nor actual use of mHealth, as proposed. Voluntariness was a significant negative predictor of both intention to use and actual use of mHealth, as has been found in some studies (Venkatesh & Davis, 2000), including among other healthcare professionals (Kifle et al., 2010). These results suggest that when mHealth use was optional, nurses had less intention to use and actual use of mHealth. There is mixed support for the importance of voluntariness in predicting intention to use mHealth and technology (Mbelwa et al., 2019; Venkatesh & Davis, 2000). With regard to considering the effects of voluntariness on intention to use, a small effect size was found for the addition of voluntariness (Cohen, 1988). This small effect size limits the interpretation of this finding in terms of practical implications (Griffiths & Needleman, 2019). As such, the small effect of voluntariness on intention to use mHealth may provide some reassurance when interpreting these results in the context of health systems where use of HIT systems is typically mandatory and do not allow for voluntariness of use to be considered. When considering nurses' actual use of mHealth however, a medium effect size was found for the addition of voluntariness which suggests that there may be moderate practical implications when considering the effects of voluntariness on nurses' actual use of mHealth (Griffiths & Needleman, 2019). The practical implications of this finding can be interpreted in different ways. One message that can be gleaned from this finding is that making mHealth use mandatory in healthcare settings – which reflects the reality of health information technology implementation currently – is necessary to optimize nurses' intention to use and actual use of mHealth. Indeed, this approach is the most common way that implementations of mHealth and other health information technologies are conducted in healthcare systems. A challenge with this approach however is the inability to understand the reasons behind why nurses may be resistant to or do not adequately adopt and use these “mandatory to use” technologies, which is the current status quo. While individual-level characteristics undoubtedly play a role in shaping use behaviours, broader structural and contextual variables also play an important role. Another important consideration is the overall inadequate understanding of the role of leadership in influencing technology use in mandatory settings. Indeed, there is little research on voluntary technology use (versus mandatory technology use) as related to HIT in healthcare systems; voluntariness is more typically examined in the context of enterprise systems in business (Rezvani et al., 2017). One potential interpretation of the negative relationships between voluntariness and the intention to use and actual use of mHealth is that, when given the option, nurses’ may choose to not use mHealth as a result of perceived insufficient support for the use of mHealth in practice or poorly designed technologies that do not support nursing practice and workflows (Hardiker et al., 2019; Mather & Cummings, 2017; Mather et al., 2018; Schachner et al., 2016; Staggers et al., 2018; Topaz, Ronquillo, Peltonen, Pruinelli, Sarmiento, Badger, Ali, Lewis, Georgsson, Jeon, et al., 2016; Zadvinskis et al., 2018). Finally, it is important in the interpretation of these results to consider that although voluntariness reduced intention to use and actual use, actual use rates are low among all participants, whether use of the technology is voluntary or mandatory.

5.4 Contributions to Theory

The contribution of this study to continued theoretical development related to the understanding of nurses’ use of mHealth is discussed in this section. First is the demonstration that a technology acceptance model can serve as a suitable “base” model that can be expanded to include additional variables. While recognizing that technology acceptance models are not complete models, the adaptation presented in this study contributes to capturing the complexity of healthcare underpinned by a well-established theoretical framework. Indeed, the relationships between categories of variables that were examined in this study (individual, technological, and implementation characteristics) are the same as those included in previous studies that have been able to account for the majority of the variance in healthcare professionals' use of hospital information systems (Aggelidis & Chatzoglou, 2009), suggesting that these factors may warrant continued exploration. The findings in the study provide insight into the suitability of using an adaptation of a technology acceptance model to understand mHealth use by nurses in the complex world of health systems and contributes to addressing the critique regarding the validity of technology acceptance models in populations beyond the "typical" students and corporate employees where such models are often tested (Legris et al., 2003). However, the negative relationship between voluntariness and mHealth use contradicts findings in previous studies, highlighting the need to reconsider the role of voluntariness in the context of healthcare environments where the introduction of new technologies is typically mandatory.

The inclusion of leadership in the conceptual model, informed by established relationships within nursing and emergent developments in implementation science, is another important contribution of this study. The explicit conceptualization of implementation leadership as referring to specific behaviours of first-level leaders, helps to clarify the concept of leadership as related to implementation in healthcare (Li et al., 2018) and provides specificity related to the role of leadership characteristics in influencing technology adoption practices (Van Wart et al., 2017). Results from this study are in line with ongoing work that have found similar significant associations between high levels of implementation leadership of first-level leaders and the successful implementation of other types of innovations in healthcare (e.g., evidence-based practice (Farahnak et al., 2019; Williams et al., 2020)). This specificity in addressing implementation leadership behaviours directly addresses the conclusion of a recent concept analysis of implementation leadership that speaks to the continuing evolution of the term and need for further clarification (Castiglione, 2019). "Although research has identified many leadership variables that influence implementation, their incorporation into a theory has been incomplete and insufficiently tested" (Gifford et al., 2017, p. 16); this study contributes to these emergent developments related to the understanding of implementation leadership characteristics in the context of mHealth implementation and use in nursing.

To my knowledge, this study also illustrates the first use of the implementation leadership scale as related to technology implementation in nursing. Psychometric assessment of the ILS showed that the scale performed as it has in the past, suggesting that it is reliable measure of implementation leadership characteristics beyond the context of evidence-based practice, suggesting a wider relevance of this concept. This reflects recent research that has investigated implementation leadership in other ways, for example, its impact on implementation citizenship (Aarons et al., 2017; Finn et al., 2016; Lyon et al., 2018; Powell et al., 2017) (i.e., staff behaviours that support evidence based practice (Ehrhart et al., 2015)).

5.5 Strengths and Limitations

There are four key strengths associated with this study. The first strength relates to the focus on implementation leadership characteristics as a focused way of explicating the nature of leadership and understanding the influence of specific leadership behaviours of first-level leaders on nurses' mHealth use. Understanding the role of specific implementation leadership characteristics allows for greater opportunity to make the findings from this study actionable, as they are able to point to specific behaviours of first-level leaders as well as important considerations that need to be made when implementing mHealth in nursing and optimizing mHealth use among nurses. The second key strength relates to the unique consideration and inclusion of implementation leadership in the understanding of mHealth use among nurses. The conceptual model underpinning this study effectively brings together some of the most recent developments in implementation science related to the role of leadership, drawing from and recognizing the longstanding importance and impacts of leadership in nursing. The third strength of this study relates to the sufficient power achieved, providing confidence in study validity. The fourth strength of this study relates to the inclusion of nurse demographic characteristics, in particular, those that have been found to have inconsistent influence on intention to use and actual use and the limited applicability of previous studies to the unique contexts of nursing. Findings from this study provide insight into the roles of education and age as important moderating variables when using technology acceptance models in nursing.

Along with study strengths are three key limitations that warrant caution in the interpretation of the study findings. The first limitation relates to sampling procedures and the resulting composition of the study sample. Respondents were restricted to those who spoke English which excludes French-speaking nurses in Canada who do not also speak English. As it was beyond the scope of this study to conduct the study in two languages, information was missed from nurses in French-speaking regions of the country. Furthermore, the breakdown of respondents by provinces in this study are not representative of the broader Canadian nursing workforce due to large variability in recruitment success among provinces. The majority of responses were from Saskatchewan (44.4%, n = 128), followed by Alberta (21.9%, n = 63). It is important to note that processes for study recruitment via RN provincial and territorial registration bodies varied widely and are reflected in the numbers of participants recruited from each geographic location. In particular, both Saskatchewan and Alberta had streamlined and efficient processes for recruiting among their RN registrants established. The option to agree to be contacted for the purpose of research recruitment was a standard part of the RN license registration and renewal processes in these provinces at the time of data collection for this study. As such, these RN registration bodies had mailing lists of potential RN research participants that could be made readily available to researchers, upon receiving the appropriate administrative and ethical approvals. In both provinces, the regulatory bodies maintained lists of RNs who agreed to be contacted for the purpose of research recruitment and were therefore able to facilitate expedient access to these registrants. Moreover, both provinces had established processes and procedures in place for researchers who wished to recruit through their regulatory bodies. The particularly high response rates from Saskatchewan is likely reflective of two key ways that the regulatory body supported the recruitment efforts of this research study that reflect best practices in Web survey implementation (Dillman et al., 2014). First, the survey advertisement was sent directly from the regulatory body (versus the researcher) to recipients, providing legitimacy and trust in the contents of the email. A second key difference in recruitment in Saskatchewan was the provision of recurring email reminders (2 follow-up emails) that were sent out to participants, that was a standard service that was provided by their research support office. In contrast, other regulatory bodies required additional fees for this service, resulting in the inability to pursue these reminders given the available resources. In contrast, the lowest number of respondents in this sample is from Ontario, despite being among the most populous provinces in Canada. The process in Ontario for recruiting RNs who have indicated consent to receive research related materials was limited to physical mail. While these are only two examples, they are reflective of the variability of reach and success of participant recruitment among the provinces and territories.

A second limitation relates to some of the study measures used. The critiques of the measure intention to use as a proxy for actual use has been discussed, at length, in an earlier section (see Section 2.5). Although a validated instrument was used to measure actual use in this study, it is possible that if system logs of actual mHealth use were collected, the frequency and nature of mHealth use by nurses could be more accurately measured and provide additional insight into the potential meaningfulness of each measure of mHealth use. For example, understanding the purpose for mHealth use as indicated by self-reports can provide insight as to whether greater amounts of time spent using the system is a meaningful indicator of successful mHealth use or if it shows problems with the mHealth.

A third limitation relates to the use of an online survey. As with any research method, this method of data collection has limitations. For one, the online recruitment and survey approach with non-probability sampling did not make it possible to estimate response rates and limited the ability to make explicit plans for mitigating low response rates. As such, the limitations of the sampling frame in terms of ability to represent the national nursing population was anticipated. A related limitation of this study was the inability to pursue means of recruitment beyond the online survey given budgetary and time constraints. Reviews of studies that have employed online survey methods also highlight common pitfalls, including the potential for selection bias (by limiting participation to individuals who have Internet access and/or spend the most time on social media communities), poor survey design, challenges with recruitment, and low response rates, when compared to paper surveys (Cho et al., 2013; Hunter, 2012; Khatri et al., 2015; VanGeest & Johnson, 2011). The development of more systematic online survey methods and robust tools in recent years have arguably resulted in increased effectiveness of online survey approaches, lessening the impact of a number of the aforementioned concerns. Although low response rates were observed among studies conducted in the 2000's and the suggestion made that there would be a limited increase in effectiveness in online surveys of healthcare providers in the future (Dykema et al., 2013), more recent studies seem to suggest otherwise. For example, it has been shown that web surveys can achieve high numbers of responses in relatively short periods of time (Dowding et al., 2013; LeBlanc et al., 2014; Topaz, Ronquillo, Peltonen, Pruinelli, Sarmiento, Badger, Ali, Lewis, Georgsson, & Jeon, 2016). Furthermore, other studies that have compared online versus paper-and-pencil survey methods provide further support for the general equivalency of response rate that can be achieved with either method of data collection (Gosling et al., 2004; Weigold et al., 2013), as well as other comparable features such as potentials for other types of biases (Dodou & de Winter, 2014).

5.6 Implications for Nursing Leadership

Implementation leadership was found in this study to influence nurses' actual use of mHealth in nursing practice, suggesting that specific behaviours of first-level leaders can play a role in facilitating nurses' mHealth use. First-level leaders responsible for the introduction and ongoing use of mHealth in nursing practice may therefore benefit from developing an awareness of the potential effects of specific implementation leadership knowledge and skills as they relate to the implementation of mHealth for nurses who provide direct patient care. It is likely that first-level leaders already embody some dimensions of implementation leadership as these apply to the implementation of innovations beyond mHealth; these dimensions include demonstrating that they are proactive in their approach, knowledgeable about the innovation being implemented, perseverant through the inevitable ups and downs of implementation, and supportive of nurses' use of the innovation. The development of these implementation leadership characteristics as specific to mHealth, however, likely require additional focus. To demonstrate being proactive in the context of mHealth implementation for example, specific knowledge about the mHealth technology and information technology infrastructure (resources and governance) in the health system is a pre-requisite, (Ingebrigtsen et al., 2014) in order to identify the obstacles that need to be mitigated and to inform the clear standards for implementation that need to be established in the department. Demonstrating knowledgeable leadership may be a particular area of challenge for first-level leaders as this requires being able to answer staff questions about the mHealth technology in question and being able to demonstrate that they "know what they are talking about" when it comes to the mHealth technology (Ingebrigtsen et al., 2014). Active research into nursing informatics competencies has highlighted the need for development of health and nursing informatics skills and competencies among leaders in nursing (Collins et al., 2017; Honey et al., 2016; Strudwick et al., 2019). In the context of mHealth, and indeed, any other HIT implementation by first-level leaders, nursing informatics competencies serve as a foundational knowledge base from which leaders can then build on to better understand mHealth technologies. In turn, this foundational knowledge comprises a key component of being able to demonstrate knowledgeable implementation leadership. Demonstrating supportive leadership is a dimension of implementation leadership that is likely more broadly applicable and potentially an area of existing strength for many first-level leaders, as this entails demonstrating recognition and support of employee efforts to learn more and use mHealth. Similarly, demonstrating perseverant leadership in the context of mHealth implementation is likely broadly applicable (Sligo et al., 2017), as this relates to demonstrating the leaders' tenacity and persistence to see the implementation through barriers and challenges encountered and react to critical issues that arise along the way.

It will be important to consider the attenuating effect of age on the relationship between implementation leadership characteristics and mHealth use. It is possible that approaches of first-level leaders and resources necessary to support nurses use of mHealth in practice will differ according to nurses' age. First-level leaders may need to employ varying approaches for different age groups of nurses, although it was beyond the scope of this study to explore this hypothesis. It is also important to note that results from this study provide greatest insight for those in first-level leadership roles (i.e., those who have direct oversight for nurses in clinical practice), being mindful of recommendations from previous studies that have suggested that there may also be variability in determining the most suitable leadership behaviours to achieve intended implementation goals according to the level of leadership involved (Sligo et al., 2017).

Results from this study highlight that it is important for first-level leaders to recognize the importance of voluntariness of use influencing nurses' intention to use and actual use of mHealth. Given that voluntariness of use is likely beyond the control of first-level leaders, awareness of the attenuating effects of mandatory use of mHealth is important in being able to understand the success or otherwise of mHealth implementation efforts. For example, this may require first-level leaders to advocate for questioning the design and suitability of the technologies that are more often than not, mandated, in nursing.

Developments in leadership theory related to the concept of multilevel leadership is also worth noting, as it is possible that there may be interactions between implementation leadership characteristics and multilevel leadership that ultimately influence nurses' use of mHealth. Briefly, the concept of multilevel leadership refers to the shifting view of leadership from focusing on individuals as leaders towards a view of leadership that considers the collective, where there is shared and distributed leadership (Yammarino et al., 2012). For example, there have been investigations into the relationship between top and middle managers' (i.e., first-level leaders) leadership characteristics (multilevel leadership) in healthcare, finding a mediating role of middle managers' implementation leadership on the relationship between top managers and the implementation of evidence-based practices among staff (Guerrero et al., 2020). In the context of mHealth use, considering the concept of multilevel leadership in relation to implementation leadership characteristics may warrant exploration of the role of super users and other influential (though often informal) leaders, who are known as key players in supporting technology implementation and use (Collins et al., 2015; Registered Nurses Association of Ontario, 2017).

5.7 Future Research Directions

A number of new research questions have emerged from this study that warrant further exploration. The attenuating effect of age on the relationship between implementation leadership characteristics and the actual use of mHealth is an area for future research, in line with recommendations to develop deeper insights into the applicability of implementation leadership

(Castiglione, 2019). Although this study provides detail regarding the nature of leadership in relation to mHealth implementation in nursing, further delineation of the concept of implementation leadership should be explored. In particular, qualitative exploration of nurses' knowledge of the titles, roles, responsibilities, available resources and constraints of the first-level leaders responsible for the implementation of and ongoing use of mHealth in healthcare systems may provide important contextual information to aid in interpreting the relationships found between implementation leadership characteristics and nurses' mHealth use. Several other research directions can be explored related to actual use of mHealth, including examining the relationships in the various dimensions of actual use, relationships between types and functionalities of mHealth and use, and relationships between intention to use and the dimensions of actual use, all of which can contribute to a more nuanced understanding of what a meaningful measure of actual use might be in the context of nursing.

The role of voluntariness is an area to be explored. As found in this study, nurses had lower intention to use and actual use of mHealth when the option was voluntary. This relationship presents a particular challenge given the typically mandatory nature of technology implementations in health systems. On one hand, these findings can be interpreted as supporting the mandatory nature of mHealth implementation, given the negative effects of voluntariness. On the other hand, it has been found that that poor design and lack of usability of HIT are associated with low rates of use and the use of workarounds (Gagnon et al., 2012; Tang et al., 2018; Topaz, Ronquillo, Peltonen, Pruinelli, Sarmiento, Badger, Ali, Lewis, Georgsson, & Jeon, 2016; Walker & Clendon, 2016). A further clarification of the role of voluntariness is needed to tease apart whether the negative effects on intention to use and actual use result from the voluntary nature of the technology use itself, or, whether the decision to use a technology in voluntary settings are a result of technology characteristics. Building directly from this research, an initial approach would be to examine the potential moderating effects of voluntariness on usefulness and ease of use. Other future research should explore the relationships between voluntariness, usability of mHealth, nurses' engagement with the system development life cycle, and nurses' assessments of the suitability of systems to support workflows and clinical practice. For example, would there be any change in the impact of voluntariness or in willingness to use mHealth with better design of mHealth and technologies in general?

Future research can also examine unique technology characteristics of mHealth and their influence on the nature of nurses' use behaviours. In this future stream of research, it will be important to develop an understanding about the technology characteristics of mobility, portability, and usability of mHealth and the extent to which these characteristics are reflected in the types of mHealth devices used by nurses and the functions that the mHealth performs. This line of work can provide insight into the nature of nurses' mHealth needs and how well current mHealth solutions are able to address those needs. For example, do nurses primarily use mHealth that are highly portable and mobile (e.g., smartphones) at the bedside and another type of mHealth when away from the bedside (e.g., laptops)? Furthermore, what do these patterns of use suggest with regard to the dynamics between nurse-patient relationships and mHealth use?

With regard to leadership, future research should explore the degree to which first-level leaders have control over the planning and implementation of mHealth as a way to distinguish between the effects of voluntariness with other potential variables that may influence mHealth use among nurses. An example of a research question to explore the aforementioned could be: To what degree do first-level leaders have the authority to choose the implementation approach (e.g., phased implementation with feedback and re-design cycles rather than full-scale implementation)?

5.8 Conclusion

The successful implementation, use, and integration of mHealth into nursing workflows is an important step towards realizing the envisioned benefits of mHealth use to improve healthcare systems. In this study, graduate level education was found to attenuate the effects of implementation leadership characteristics on nurses' intention to use mHealth. Specifically, implementation leadership had greater influence on intention to use mHealth among nurses with an RN diploma or a Bachelor of Nursing Degree as compared to nurses with Graduate or other advanced practice degrees. Implementation leadership characteristics were also found to be important predictors of nurses' actual use of mHealth. This suggests that first-level leaders' behaviours that are specific to how they implement mHealth influence nurses' use of mHealth in their practice. To ensure success of mHealth implementations in nursing therefore requires that leaders responsible for mHealth implementation can demonstrate that they are proactive, knowledgeable, supportive, and perseverant. Age was found to attenuate the effects of implementation leadership, where implementation leadership had a greater influence on the actual use of mHealth among nurses 49 years old and under. Taken together, the attenuating effects of education and age on implementation leadership, suggest that it may be necessary to employ different strategies to promote the use of mHealth by nurses of different education and age groups.

This study found that nurses' perceptions of whether or not mHealth was useful was an important predictor of both their intention to use and actual use of mHealth, confirming well-established relationships that have been found in previous research. This finding emphasizes the importance of involving nurses' early and in all stages of the system development life cycle; ensuring early assessments of nurses' perceptions of mHealth to be deployed can ultimately determine the success or failure of the mHealth implementation. Nurses' perceptions of whether mHealth was easy to use was also found to influence nurses' intention to use technology and points to another area of early assessment that should be examined when planning an mHealth implementation. Finally, whether mHealth use was deemed mandatory or voluntary was found to influence nurses' intention to use and actual use of mHealth, with voluntary use resulting in lower intention to use and actual use of mHealth. This presents a potential challenge within healthcare settings where the implementation of new technologies is typically mandatory. New questions are raised from this study and future research directions are necessary to better interpret the implications of these results for clinical practice. Future research directions should focus on a more detailed investigation to better understand and perhaps tease apart effects of voluntariness and the usability of the mHealth technology in question, as other research suggests that challenges with usability can be a possible explanation for this relationship.

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Appendices

Appendix A MOBILE Study Questionnaire

Standard: QUESTIONNAIRE PAGE 1 - Study eligibility (5 Questions)
Standard: Section A – Use of mobile health technologies (mHealth) at work (10 Questions)
Standard: Block 3 (1 Question)
Standard: Section B – Perspectives and opinions about your mHealth use at work (1 Question)
Standard: Section C– mHealth leader role and characteristics (3 Questions)
Standard: Section D – USE of mHealth and other mobile technologies outside of work (8 Questions)
Standard: Section E – Nurse (15 Questions)
Standard: Section F – Your comments (Optional) (2 Questions)

SURVEY LANDING PAGE & CONSENT

Q1 **M-Health and Implementation Leadership Evaluation (MOBILE) Nurse Study**

Thank you for your interest in this study. This survey is about the factors that may influence **your use of mobile health technologies (mHealth) in your nursing work**. In particular, we would like to learn about **mHealth that your workplace provides you with,** as a tool in your nursing work. Your responses are very valuable in this research and will help me, and others, to understand how mHealth is implemented in nursing settings and how mHealth is used by nurses.

In this survey, mHealth refers to the use of mobile and portable information and communication devices as a tool in your nursing work. Devices that you might use for mHealth include handheld computers, personal digital assistants (PDAs), mobile phones (basic and smart phones), tablet computers, laptops, wearable devices, and mobile sensing technologies.

To be eligible for this study, you must:

- Hold Registered Nurse licensure in Canada.
- Provide direct patient care in any setting.
- Have access to workplace-provided mHealth for use in your nursing work.
- Speak English.

The survey includes questions about your mHealth use at work, characteristics of the mHealth that you use, your views about how mHealth has been introduced and deployed in your workplace, and the type of setting that you work in.

The survey will take about 15-20 minutes to complete and consists of 5 sections. Please complete this survey at a time that is most convenient for you. You will have the option to stop the survey and continue later if you are not able to complete it in one sitting.

All your answers will remain **confidential** and **anonymous**. **NO ONE** at work will ever see your answers. To safeguard the privacy of your answers, you will not be asked to provide any personal identifying information. You do not have to answer any questions you are not comfortable with and can withdraw from the study at any time.

Please be aware that liking, sharing, or following this page via social media may result in your profile being publicly linked to this study, depending on your privacy settings.

Prizes will be given! We will be conducting a weekly prize draw for an electronic Amazon gift certificate worth $15 CAD for each week the survey is active. The survey is active for 22 weeks, for a total of 22 prize draws. You will be entered in each week's prize draw from the time you submit the survey. Prize draw winners will not be re-entered into further weekly prize draws

You will be entered in the prize draw each week, up to a total of 22 times. However, if you win the prize draw at week 6, you will not be entered in the prize draws that follow.

ALL participants will be entered into the GRAND prize draw for an electronic Amazon gift certificate worth $150 CAD at the end of the survey!

To ensure your confidentiality, the email that you provide to enter the prize draw will be separated from the rest of your responses. Your responses will NOT be linked to your prize draw entry.

By starting and completing the questionnaire, you are providing consent to participate and confirm your understanding of the research study. Your responses will be automatically submitted at the end of the survey. THANK YOU FOR YOUR PARTICIPATION!

- ○ I consent, begin the study
- ○ I do not consent, I do not wish to participate

QUESTIONNAIRE PAGE 1 - Study eligibility

SE Study eligibility

Thank you for your interest in participating in this study. The following questions will determine if you are eligible to participate. Please answer Yes or No to each question.

As a reminder, mobile health technologies (mHealth) refer to the use of mobile and portable information and communication devices as a tool in your nursing work.

SE1 Do you have **access to workplace-provided mHealth** in your **primary nursing job**?

◯ Yes

◯ No

SE2 Do you hold **licensure as a Registered Nurse, Registered Practical Nurse, or Nurse Practitioner in Canada**?

◯ Yes

◯ No

SE3 Do you **provide direct patient care**?

◯ Yes

◯ No

SE4 Do you **speak English**?

◯ Yes

◯ No

End of Block: QUESTIONNAIRE PAGE 1 - Study eligibility

Section A – Use of mobile health technologies (mHealth) at work

Please read through each item carefully before responding. It is important that you answer each question as thoughtfully and honestly as possible. There are no right or wrong answers, only your individual opinions. Your answers are important to this research study.

The following questions are about **YOUR use of workplace-provided mHealth in your primary nursing job.** In this survey, mHealth refers to the use of mobile and portable devices as a tool in your nursing work.

Reminder: Devices used for mHealth include personal digital assistants (PDAs), mobile phones (basic and smart phones), laptops, tablet computers, wearable devices, and mobile sensing technologies. If the mHealth device that you use is not listed as an option, you will have the option to write in the name of the device.

Important: If you **work in more than one nursing setting that provides access to mHealth**, please answer for the setting you consider **your primary nursing job**.

A1 When did you FIRST use any workplace-provided mHealth in your primary nursing job? Please provide your best estimate of the date.

	Month	Year
I first used workplace-provided mHealth in my primary nursing job on...	▼ January (1 ... December	▼ 1990 (1 ... 2018 (29)

A2 When was the **LAST TIME** you used any **workplace-provided mHealth in your primary nursing job**? Please provide **your best estimate of the date**.

	Month	Year
The last time I used mHealth in my primary nursing job was on:	▼ January (1 ... December	▼ 1990 (1 ... 2018 (29)

A3 On average, how much **time** do you spend **using workplace-provided mHealth each shift**?

On an average shift, I use mHealth for

○ hours ____

○ minutes ____

A4 **How many** workplace-provided mHealth tools do you use in your **primary nursing job**?

○ 1

○ 2 or more (please name all devices)

____

Display This Question:
If A4 = 2

A4.1 You've indicated that **you use more than one** workplace-provided mHealth tool. Do you **use some mHealth more than others?**

- ◯ Yes (please explain briefly) ____
- ◯ No (please explain briefly) ____

A5 For the following questions, think about the workplace-provided **mHealth that you use the most**. If you use more than one mHealth device equally, please **CHOOSE ONE of mHealth device** to answer the remaining questions of the survey.

Definition: The **core mHealth hardware** refers to the **physical device** that that is used to access the mHealth functionalities. For example, a mobile documentation functionality may be accessed through a smart phone, tablet, or laptop. In this example, the "core" mHealth hardware are the smart phone, tablet, and laptop.

What is the **core mHealth hardware** that you use in your primary nursing job? Please choose **ONE** response.

- o Mobile phone without data access
- o Smart phone (please indicate of iPhone, Android, Other [please indicate], or "I don't know")
- o Tablet (please indicate if iPad, Android, Other [please indicate], or "I don't know")
- o Laptop
- o Other (please describe) ____

A6 Do you use any additional attachments with the core mHealth hardware?

- o Yes
- o No

Display This Question:
If A6 = 2

A6.1 You have indicated that you use additional attachments with the core mHealth hardware.

Please select **ALL** the attachment options that you use, from the list below.

- ☐ **Mobile attachments** (Physical hardware attachments that typically allow for capturing reading or other biomedical information, but can have a different purpose)
- ☐ **Connected devices** (Devices that do not physically connect to the core device but may be connected wirelessly. Examples include Bluetooth blood glucose meters and Bluetooth weight scales)
- ☐ **In vivo sensors** (Sensors embedded under the (patient's) skin or ingested into the body that can communicate with mobile devices. One example is a glucose monitor that is injected under the skin)
- ☐ **Other** (please describe) ____

A7 Below are a list of common functions of mHealth. Please check **ALL** boxes that refer to **what YOU use mHealth for, in your primary nursing job**.

For each box you check, please briefly describe how you use this function.

- ☐ General/basic documentation (Please describe…)
- ☐ Medication documentation (e.g., barcode) (Please describe…)
- ☐ Care plans (Please describe…)
- ☐ View patient information (Please describe…)
- ☐ Discharge planning (Please describe…)
- ☐ Support decision making (e.g., risk assessment) (Please describe…)
- ☐ Accessing information resources (e.g. medication information) (Please describe…)
- ☐ Patient and/or family teaching (Please describe…)
- ☐ Communicate with patients (e.g., schedule appointments) (Please describe…)
- ☐ Communicate with professionals outside of health care (e.g. social care, housing, social support, etc.) (Please describe…)
- ☐ Communicate with other non-health care professionals (e.g. social care, housing, social support, etc.) (Please describe…)
- ☐ Coordinate staff rostering (Please describe…)
- ☐ Other (Please describe…)

Block 3 - ADoll&Tork - USE

This following statements refer to **HOW and WHAT** you use workplace-provided mHealth for in your nursing work. You will notice that some of the statements are similar, but it is important that you answer **ALL** statements. Once again, please answer **each one** to the best of your ability. Please read each statement carefully and decide **HOW MUCH each statement applies to you.** **SELECT** only **ONE** answer for each question. There are no wrong or right answers.	0 Not at all	1 A little	2 Moderately	3 Much	4 A great deal
1. I use mHealth to **decide** how to best **approach a health care problem**.	○	○	○	○	○
2. I use mHealth to **help me think through health care problems.**	○	○	○	○	○
3. I use mHealth to **check my clinical judgment against the data.**	○	○	○	○	○
4. I use mHealth to help me **explain my clinical decisions.**	○	○	○	○	○
5. I use mHealth to **control or shape** the **clinical decision process.**	○	○	○	○	○
6. I use mHealth to **improve the effectiveness and efficiency** of the **clinical decision process.**	○	○	○	○	○
7. My nursing team and I use mHealth to **coordinate our activities**.	○	○	○	○	○
8. I use mHealth to **coordinate care activities** with nurses in my nursing team.	○	○	○	○	○
9. I use mHealth to **exchange information** with nurses in my nursing team.	○	○	○	○	○
10. I use mHealth to **keep my superiors informed** of my care activities.	○	○	○	○	○
11. I use mHealth to **exchange information with people who report to me** (orderlies, nursing associates, clerk, etc.).	○	○	○	○	○
12. I use mHealth to **deal more efficiently with the nursing care I provide** to my patients.	○	○	○	○	○
13. I use mHealth to **personalize more the care for my patients.**	○	○	○	○	○
14. I use mHealth to **exchange information with patients.**	○	○	○	○	○
15. I use mHealth to **communicate with patients.**	○	○	○	○	○

Section B – Perspectives and opinions about your mHealth use at work

B: Voluntariness, Perceived usefulness, Perceived Ease of Use, Intention to use

	The following fifteen statements are about YOUR perspectives and opinions about the workplace-provided mHealth as a tool in your nursing work. You will notice that some of the statements are similar, but it is important that you answer ALL statements. Please read each statement carefully and decide if YOU disagree or agree with each perspective or opinion statement. SELECT only ONE answer for each question. There are no wrong or right answers.	1Strongly Disagree	2Moderately Disagree	3Somewhat Disagree	4Neutral (neither disagree nor agree)	5 Somewhat Agree	6 Moderately Agree	7 Strongly Agree

V	1. My use of mHealth is voluntary							
V	2. My supervisor does not require me to use mHealth.							
V	3. Although it might be helpful, using mHealth is certainly not compulsory in my job.							
PU	4. Using mHealth improves my performance in my job.							
PU	5. Using mHealth in my job increases my productivity.							
PU	6. Using mHealth enhances my effectiveness in my job.							
PU	7. I find mHealth to be useful in my job.							
PE OU	8. My interaction with mHealth is clear and understandable.							
PE OU	9. Interacting with mHealth does not require a lot of my mental effort.							
PE OU	10. I find mHealth to be easy to use.							
PE OU	11. I find it easy to get mHealth to do what I want it to do.							
BI	12. Assuming I had access to the mHealth, I intend to use it.							
BI	13. Given that I had access to the mHealth, I predict that I would use it.							
BI	14. I plan to use the mHealth in the next month.							

Section C– mHealth leader role and characteristics

C1 – Implementation leadership

The following questions are about the person(s) responsible for introducing and the ongoing mHealth use in your workplace. Please SELECT the response option that best represents your answer.

What is the formal title of the person responsible for introducing mHealth in your primary nursing job?

- Unit or department manager
- Charge nurse
- Clinical nurse educator
- Resource person from outside your unit or department (please indicate his/her title and describe their role)
- Other *(Please describe)* ____

C2 What is the **formal title** of the person responsible for **ongoing mHealth use** in your primary nursing job?

- Unit or department manager
- Charge nurse
- Clinical nurse educator
- Resource person from outside your unit or department (please indicate his/her title and describe their role)
- Other *(Please describe)* ____

C3 The following statements refer to **YOUR** perspectives on how mHealth has been introduced in your work place.

You will notice that some of the statements are similar, but it is important that you answer **ALL** statements. Once again, please answer **each one** to the best of your ability.

Please read each statement carefully and indicate **to what extent** you feel **the statement applies to the person responsible** for i**ntroducing mHealth in your primary nursing job.** In the following statements, this person will be referred to as the **mHealth leader.**
SELECT only **ONE** answer for each question. There are no wrong or right answers.

Section C (cont'd…)

Implementation leadership characteristics

		0Not at all	1 Slight extent	2 Moderate extent	3 Great extent	4 Very great extent
Pro	1. The mHealth leader has **developed a plan** to facilitate implementation of mHealth.					
Pro	2. The mHealth leader has **removed obstacles** to the implementation of mHealth.					
Pro	3. The mHealth leader has **established clear department standards** for the implementation of mHealth.					
K	4. The mHealth leader is **knowledgeable about mHealth.**					
K	5. The mHealth leader is **able to answer my questions about mHealth.**					
K	6. The mHealth leader **knows what he or she is talking about when it comes to mHealth.**					
S	7. The mHealth leader **recognizes and appreciates employee efforts towards successful implementation** of mHealth.					
S	8. The mHealth leader **supports employee efforts to learn more about mHealth.**					
S	9. The mHealth leader **supports employee efforts to use mHealth.**					
Pers	10. The mHealth leader **perseveres** through the ups and downs of implementing mHealth.					
Pers	11. The mHealth leader **carries on** through the challenges of implementing mHealth.					
Pers	12. The mHealth leader **reacts to critical issues** regarding the implementation of mHealth by **openly and effectively addressing the problem(s).**					

Section D –
Previous experience with non-work mobile

D1 **Reminder: Mobile devices** refer to portable and mobile technologies such as personal digital assistants (PDAs), mobile phones (basic and smart phones), laptops, tablet computers, wearable devices, and mobile sensing technologies. **mHealth** refers to the use of these mobile devices for health purposes. If the mobile device that you use is not listed as an option, you will have the option to write in the name of the device.

The following questions are about your use of **mobile devices for non-health purposes.** Examples of mobile use for non-health purposes include text messaging, playing games on a tablet, or using a laptop to access the Internet.

Do you **currently use** any mobile device(s) **outside of work?**

- ◯ Yes
- ◯ No

Display This Question:
If D1 = 2

D1.1 You've indicated that you use mobile device(s) outside of work. When was the first time you EVER used a mobile device outside of work?

	Month	Year
The first time I used a mobile device outside of work was on:	▼ January (1 ... December	▼ 1990 (1 ... 2018 (29)

Display This Question:
If D1 = 2

D1.2 **What mobile device(s)** do you **currently use outside of work?**
Please check **ALL** that apply.

- ☐ Tablet computer
- ☐ Mobile phone (without Internet access)
- ☐ Smart phone (cellular phone with internet access)
- ☐ Laptop computer
- ☐ Wearable device (for example, smart watch)
- ☐ Other (Please describe) ____

Display This Question:
If D1 = 2

D1.3 On average, h**ow much time each day** do you spend **using ALL the mobile device(s)** that you **currently use** outside of work? Please indicate in hours and minutes.

The total amount of time I spend using ALL my mobile devices each day is:

- hours ____________
- minutes _________________________

Previous experience with non-work mHealth
D2 The following questions are about your use of **mHealth OUTSIDE of work**. This refers to your use of **mobile devices for health purposes.**

Examples of mHealth use outside of work include tracking your physical activity with an activity monitor bracelet, tracking your diet with a tablet application, or monitoring your sleep trends with a smart phone application.

Do you currently **use mHealth OUTSIDE of work?**

- ○ Yes
- ○ No

Display This Question:
If D2 = 2

D2.1 You've indicated that you use mHealth outside of work. When was the first time you EVER used mHealth outside of work?

	Month	Year

The first time I used mHealth outside of work was on:	▼ January (1 ... December	▼ 1990 (1 ... 2018 (29)

Display This Question:
If D2 = 2

D2.2 **What mHealth devices** do you **currently use outside of work?**
Please check **ALL** that apply.

- ☐ Tablet computer
- ☐ Mobile phone (without Internet access)
- ☐ Smart phone (cellular phone with Internet access)
- ☐ Laptop computer
- ☐ Wearable device: Smart watch
- ☐ Wearable device: Activity monitor bracelet
- ☐ Wearable device: Other type of activity monitor *(Please describe)* ________________________
- ☐ Other *(Please describe)* ____

Display This Question:
If D2 = 2

D2.3 On average, h**ow much time each day** do you spend **using ALL mHealth** devices that you **currently use** outside of work? Please indicate in hours and minutes.

- hours _____________
- minutes ____________________________

Section E – Nurse Characteristics

This section asks you general questions about your job as a nurse and background information.

Please **SELECT** the option that corresponds to your answer or, where indicated, **TYPE IN** the blanks.

E1 What **type** of registered or licensed health care designation do you hold? Please select **ALL** that apply.

- ☐ Registered Nurse (RN) or Adult nurse, Children's nurse, and Learning disabilities nurse (RN, RNC, or RNLD)
- ☐ Registered Psychiatric Nurse (RPN) or Mental health nurse (RNMH)
- ☐ Nurse Practitioner (NP)
- ☐ Registered Midwife (RM)
- ☐ Other (Please specify) ____

E2 In what **month** and **year** were you born?

	Month	Year
My month and year of birth is:	▼ January (1 ... December	▼ 1940 (1 ... 2000 (61)

E3 What is your **gender?** Please select **ONE** response.

- o Male
- o Female
- o Other (please indicate) ____
- o Prefer not to say

E4 What is your **highest** educational qualification **in nursing**? Please select **ONE** response.

- o Registered Psychiatric Nurse or Mental Health Nurse diploma
- o Registered Nurse, Adult Nurse, Children's Nurse, or Learning Disabilities Nurse diploma
- o Bachelor of Nursing
- o Master of Nursing
- o PhD (Nursing)
- o Other (Please specify) ____

E5 What is the **highest** level of **non-nursing education** that you have received? Please select **ONE** response.

- ○ Bachelor degree
- ○ Master degree
- ○ PhD
- ○ Other (Please specify) ____
- ○ Not applicable

E6 **What year** did you **obtain your first nursing qualification?**

	Year
I obtained my first nursing qualification in:	▼ 1950 (1 ... 2018 (69)

E7 **Where** do you currently work in **your primary nursing job?**
- ○ Canada
- ○ United Kingdom

Display This Question:
If E7 = 1

E7.1a Which **Canadian province or territory** is your **primary nursing job** in?
- ○ Alberta
- ○ British Columbia
- ○ Manitoba
- ○ New Brunswick
- ○ Newfoundland and Labrador
- ○ Northwest Territories
- ○ Nova Scotia
- ○ Nunavut
- ○ Ontario
- ○ Prince Edward Island
- ○ Quebec
- ○ Saskatchewan
- ○ Yukon

Display This Question:
If E7 = 2

E7.1b Which **country or region** is your **primary nursing job** in?
- ○ England
- ○ Scotland
- ○ Wales
- ○ Northern Ireland

Display This Question:
If E7 = 1

E8a What type of **population setting** is your **primary nursing job** in?

- Large urban population centre: Greater than 100,000 people and a high population density
- Medium population centre: Between 30,000 and 99,999 people and a high population density
- Small population centre: Between 1,000 and 29,999 people and a high population density
- Rural area: All other areas outside of population centres (described above)

Display This Question:
If E7 = 2

E8b What type of **population setting** is your **primary nursing job** in?

- Urban: Population of 10,000 or greater
- Rural: Population fewer than 10,000

E9 In what **sector** is your **primary nursing job**?
Please choose **ONE** response.

- Private (not publicly funded)
- Public
- Self-employed *(Please describe)* ____
- Other *(Please describe)* ____

E10 What **type of organization** is your **primary nursing job** in?
Please choose **ONE** response.

- Hospital
- Community health
- Nursing home or other long-term care facility
- Other *(Please indicate)* ____

E11 What type of **specialty area** is your **primary nursing job** in?
Please choose **ALL** that apply.

- ☐ Critical care
- ☐ Emergency care
- ☐ Maternal
- ☐ Medical
- ☐ Surgical
- ☐ Geriatrics or Older adult
- ☐ Paediatrics
- ☐ Psychiatry or Mental health
- ☐ Community or Public health
- ☐ Home care
- ☐ Occupational health
- ☐ Hospice or Palliative care
- ☐ Administration
- ☐ Correctional nursing
- ☐ Clinical or health informatics
- ☐ Other *(Please indicate)* ____

Section F – Your comments (Optional)

Q50 **Your comments (Optional)**

If you would like to provide any additional comments on the survey, the implementation and use of mHealth in nursing, or other topics, please type your comments in the text box below.

____

This is the end of the survey. Thank you very much for taking the time to complete this survey!

Please accept our sincere thanks for taking the time to participate. We truly appreciate your involvement and want you to know your responses will help us, and others, to understand how mHealth is implemented in nursing settings and how mHealth is used by nurses.

The next page provides **instructions** on how to participate in the **weekly prize draws** available to you.

By submitting this questionnaire, you are consenting to participate in this research.

Appendix B MOBILE Study Landing Page and Consent (web pages)

Mobile Health and Implementation Leadership Evaluation (MOBILE) Nurse Study

About the Study | The Study Team | What is mHealth? | Contact | Share | Tweet

M-Health and Implementation Leadership Evaluation (MOBILE) Nurse Study

Thank you for your interest in this study. This survey is about the factors that may influence your use of mobile health technologies (mHealth) in your nursing work.

January 2019 UPDATE: The survey results are currently under analysis. Thank you to those who participated in this study!

Supported by THE UNIVERSITY OF BRITISH COLUMBIA

The Study Team

Principal investigator: Leanne Currie, RN, PhD, Associate Professor

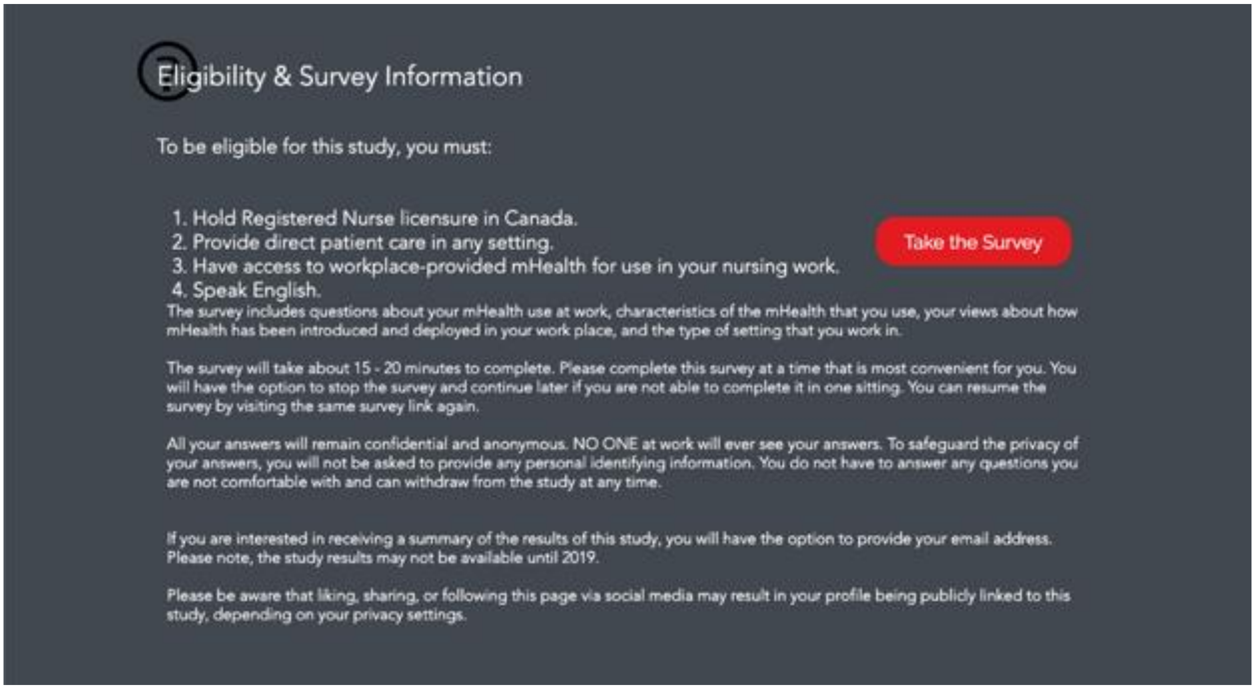
Co-investigators:
Charlene Ronquillo, RN, MSN, PhD Candidate, Dr. Susan Dahinten, RN, PhD, Associate Professor, Dr. Vicky Bungay, RN, PhD, Associate Professor.

All study investigators are affiliated with the University of British Columbia School of Nursing.

What is mHealth?

In this survey, mHealth refers to the use of mobile and portable information and communication devices as a tool in your nursing work.

Devices that you might use for mHealth include handheld computers, personal digital assistants (PDAs), mobile phones (basic and smart phones), tablet computers, laptops, wearable devices, and mobile sensing technologies.


Eligibility & Survey Information
To be eligible for this study, you must:
1. Hold Registered Nurse licensure in Canada.
2. Provide direct patient care in any setting.
3. Have access to workplace-provided mHealth for use in your nursing work.
4. Speak English.
Take the Survey
The survey includes questions about your mHealth use at work, characteristics of the mHealth that you use, your views about how mHealth has been introduced and deployed in your work place, and the type of setting that you work in.
The survey will take about 15 - 20 minutes to complete. Please complete this survey at a time that is most convenient for you. You will have the option to stop the survey and continue later if you are not able to complete it in one sitting. You can resume the survey by visiting the same survey link again.
All your answers will remain confidential and anonymous. NO ONE at work will ever see your answers. To safeguard the privacy of your answers, you will not be asked to provide any personal identifying information. You do not have to answer any questions you are not comfortable with and can withdraw from the study at any time.
If you are interested in receiving a summary of the results of this study, you will have the option to provide your email address. Please note, the study results may not be available until 2019.
Please be aware that liking, sharing, or following this page via social media may result in your profile being publicly linked to this study, depending on your privacy settings.


Prizes will be given!
We will be conducting a weekly prize draw for an electronic Amazon gift certificate worth $15CAD for each week the survey is active. The survey is active for 22 weeks, for a total of 22 prize draws. You will be entered in each week's prize draw from the time you submit the survey. Prize draw winners will not be re-entered into further weekly prize draws
For example, if you completed your survey in week 1 that the survey has been active, you will be entered in the prize draw each week, up to a total of 22 times. However, if you win the prize draw at week 6, you will not be entered in the prize draws that follow.
ALL participants will be entered into the GRAND prize draw for an electronic Amazon gift certificate worth $150CAD at the end of the survey!
To ensure your confidentiality, the email that you provide to enter the prize draw will be separated from the rest of your responses. Your responses will NOT be linked to your prize draw entry.
Download and print the study advert here
TICKET
TICKET
KEEP THIS COUPON

Mobile Health and Implementation Leadership Evaluation (MOBILE) Nurse Study

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Get in touch

Need to get in touch or have any comments for us? Please send us a message via the form below.

Name

Email *

Subject *

Message *

Send

Principal investigator: Leanne Currie, RN, PhD, Associate Professor
Co-Investigators: Charlene Ronquillo, RN, MSN, PhD Candidate, Dr. Susan Dahinten, RN, PhD, Associate Professor, Dr. Vicky Bungay, RN, PhD, Associate Professor.

All study investigators are affiliated with the University of British Columbia School of Nursing.

If you have any questions about this study or problems with the survey, you may contact Charlene Ronquillo (PhD Candidate at UBC Nursing) by phone [redacted]

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in [redacted]

Appendix C Provincial RN regulatory body processes for research survey distribution

RN registration provincial body	Process for distribution of survey materials	Final decision re: distribution via this regulatory body
College & Association of Registered Nurses of Alberta (CARNA)	Requires researcher to request research services via established regulatory body processes and payment of research services fee.	Online study advertisements were distributed via CARNA
College of Registered Nurses of British Columbia (CRNBC) and College of Nurses of Ontario	Regulatory body does not facilitate advertisement of research studies via email.	Distribution via CRNBC and CNO were not pursued.
Saskatchewan Registered Nurses Association (SRNA)	Requires researcher to request research services via established regulatory body processes and payment of research services fee.	Online study advertisements were distributed via SRNA
College of Registered Nurses of Manitoba (CRNM)	Requires researcher to request research services via established regulatory body processes and payment of research services fee	Online study advertisements were distributed via CRNM
Ordre des infirmieres et infirmiers due Québec (OIIQ)	Requires researcher to request research services via established regulatory body processes and payment of research services fee	Distribution via OIIQ was not pursued as the survey was not available in French and the majority of registrants were French-speaking
Nurses Association of New Brunswick (NANB)	Requires researcher to request research services via established regulatory body processes and payment of research services fee	Online study advertisements were distributed via NANB
College of Registered Nurses of Prince Edward Island (CRNPEI)	No established process was in place for facilitating research with their registrants.	An alternative approach was pursued and CRNPEI shared the study advertisements via the CRNPEI social media platforms
College of Registered Nurses of Nova Scotia (CRNNS)	Requires researcher to request research services via established regulatory body processes and payment of research services fee	Distribution via CRNNS was not pursued due to insufficient available funds
Association of Registered Nurses of Newfoundland and Labrador (ARNNL)	Requires researcher to request research services via established regulatory body processes and payment of research services fee	Access to mailing lists were granted and online study advertisements were distributed via email by the researcher
Registered Nurses Association of the Northwest Territories and Nunavut (RNANTU)	No established process was in place for facilitating research with their registrants.	An alternative approach was pursued by including a study poster along with a plain language article by the researcher that was included in the RNANTU monthly newsletter that is distributed to their registrants

Appendix D Principal Components Analysis Matrices

D.1 Outcome Variables

Component Matrix of the Intention to Use Scale

Item	Component 1
BI: 2. Given that I had access to the mHealth, I predict that I would use it..	.942
BI: 1. Assuming I had access to the mHealth, I intend to use it.	.935
BI: 3. I plan to use the mHealth in the next month	.765

Note. n=286; Eigenvalue for Component 1=2.348.

Pattern Matrix of the PCA for the 14-item Actual Use Scale

	Component	
	1	2
Problem solving: 1. I use mHealth to decide how to best approach a healthcare problem.	0.861	
Problem solving: 2. I use mHealth to help me think through healthcare problems.	0.928	
Problem solving: 3. I use mHealth to check my clinical judgment against the data.	0.849	
Decision rationalization: 4. I use mHealth to help me explain my clinical decisions.	0.870	
Decision rationalization: 5. I use mHealth to control or shape the clinical decision process.	0.884	
Decision rationalization: 6. I use mHealth to improve the effectiveness and efficiency of the clinical decision process.	0.805	
Horizontal integration: 7. My nursing team and I use mHealth to coordinate our activities.		0.889
Horizontal integration: 8. I use mHealth to coordinate care activities with nurses in my nursing team.		0.918
Horizontal integration: 9. I use mHealth to exchange information with nurses in my nursing team.		0.903
Vertical integration: 10. I use mHealth to keep my superiors informed of my care activities.		0.798
Vertical integration: 11. I use mHealth to exchange information with people who report to me (orderlies, nursing associates, clerk, etc.).		0.785
Patient care: 12. I use mHealth to deal more efficiently with the nursing care I provide to my patients.		0.589
Patient Care: 13. I use mHealth to personalize more the care for my patients.	0.446	0.457
Patient care: 14. I use mHealth to exchange information with patients.		0.480

Structure Matrix of the PCA for the 14-item Actual Use Scale

	Component	
	1	2
Problem solving: 1. I use mHealth to decide how to best approach a healthcare problem.	.85	
Problem solving: 2. I use mHealth to help me think through healthcare problems.	.90	
Problem solving: 3. I use mHealth to check my clinical judgment against the data.	.84	
Decision rationalization: 4. I use mHealth to help me explain my clinical decisions.	.87	
Decision rationalization: 5. I use mHealth to control or shape the clinical decision process.	.88	
Decision rationalization: 6. I use mHealth to improve the effectiveness and efficiency of the clinical decision process.	.85	.43
Horizontal integration: 7. My nursing team and I use mHealth to coordinate our activities.		.86
Horizontal integration: 8. I use mHealth to coordinate care activities with nurses in my nursing team.		.89
Horizontal integration: 9. I use mHealth to exchange information with nurses in my nursing team.		.88
Vertical integration: 10. I use mHealth to keep my superiors informed of my care activities.		.81
Vertical integration: 11. I use mHealth to exchange information with people who report to me (orderlies, nursing associates, clerk, etc.).		.76
Patient care: 12. I use mHealth to deal more efficiently with the nursing care I provide to my patients.	.55	.72
Patient Care: 13. I use mHealth to personalize more the care for my patients.	.63	.64
Patient care: 14. I use mHealth to exchange information with patients.		.51

D.2 Predictor Variables

Pattern Matrix of the PCA for the 14-item Implementation Leadership Scale

Item	Component			
	1	2	3	4
ILS Knowledgeable leadership: 1. The mHealth leader is knowledgeable about mHealth.		.84		
ILS Knowledgeable leadership: 2. The mHealth leader is able to answer my questions about mHealth.		.87		
ILS Knowledgeable leadership: 3. The mHealth leader knows what he or she is talking about when it comes to mHealth.		.93		
ILS Perseverant leadership: 1. The mHealth leader perseveres through the ups and downs of implementing mHealth.				.83
ILS Perseverant leadership: 2. The mHealth leader carries on through the challenges of implementing mHealth.				.88
ILS Perseverant leadership: 3. The mHealth leader reacts to critical issues regarding the implementation of mHealth by openly and effectively addressing the problem(s).				.79
ILS Proactive leadership: 1. The mHealth leader has developed a plan to facilitate implementation of mHealth.			.74	
ILS Proactive leadership: 2. The mHealth leader has removed obstacles to the implementation of mHealth.			.88	
ILS Proactive leadership: 3. The mHealth leader has established clear department standards for the implementation of mHealth.			.85	
ILS Supportive leadership: 1. The mHealth leader recognizes and appreciates employee efforts towards successful implementation of mHealth.	.91			
ILS Supportive leadership: 2. The mHealth leader supports employee efforts to learn more about mHealth.	.89			
ILS Supportive leadership: 3. The mHealth leader supports employee efforts to use mHealth.	.80			

Note. n=287; Oblique promax rotation with Kaiser Normalization; Eigenvalue for Component 1=8.88, Eigenvalue for Component 2=.748, Eigenvalue for component 3=.571, Eigenvalue for component 4=.456).

Structure Matrix of the PCA for the 14-item Implementation Leadership Scale

Item	Component			
	1	2	3	4
ILS Knowledgeable leadership: 1. The mHealth leader is knowledgeable about mHealth.	.689	**.932**	.685	.749
ILS Knowledgeable leadership: 2. The mHealth leader is able to answer my questions about mHealth.	.700	**.959**	.734	.746
ILS Knowledgeable leadership: 3. The mHealth leader knows what he or she is talking about when it comes to mHealth.	.685	**.967**	.720	.728
ILS Perseverant leadership: 1. The mHealth leader perseveres through the ups and downs of implementing mHealth.	.785	.736	.681	**.952**
ILS Perseverant leadership: 2. The mHealth leader carries on through the challenges of implementing mHealth.	.748	.742	.720	**.962**
ILS Perseverant leadership: 3. The mHealth leader reacts to critical issues regarding the implementation of mHealth by openly and effectively addressing the problem(s).	.720	.720	.754	**.925**
ILS Proactive leadership: 1. The mHealth leader has developed a plan to facilitate implementation of mHealth.	.628	.763	**.885**	.638
ILS Proactive leadership: 2. The mHealth leader has removed obstacles to the implementation of mHealth.	.683	.659	**.921**	.671
ILS Proactive leadership: 3. The mHealth leader has established clear department standards for the implementation of mHealth.	.624	.679	**.915**	.708
ILS Supportive leadership: 1. The mHealth leader recognizes and appreciates employee efforts towards successful implementation of mHealth.	**.949**	.676	.666	.682
ILS Supportive leadership: 2. The mHealth leader supports employee efforts to learn more about mHealth.	**.943**	.668	.656	.752
ILS Supportive leadership: 3. The mHealth leader supports employee efforts to use mHealth.	**.927**	.700	.657	.792

Note. The highest loadings are bolded and correspond with the variable loadings in the pattern matrix.

Component Matrix of the Perceived Usefulness Scale

Item	Component 1
PU: 3. Using mHealth enhances my effectiveness in my job.	.935
PU: 1. Using mHealth improves my performance in my job	.914
PU: 4. I find mHealth to be useful in my job.	.914
PU: 2. Using mHealth in my job increases my productivity.	.898

Note. n=286; Eigenvalue for Component 1=3.352.

Component Matrix of The Perceived Ease of Use Scale

Item	Component 1
PEOU: 3. I find mHealth to be easy to use.	.920
PEOU: 4. I find it easy to get mHealth to do what I want it to do.	.874
PEOU: 1. My interaction with mHealth is clear and understandable.	.787
PEOU: 2. Interacting with mHealth does not require a lot of my mental effort.	.785

Note. n=286; Eigenvalue for Component 1=2.847

D.3 Control Variable

Component Matrix of the Voluntariness of Use Scale

Item	Component 1
Voluntariness: 2. My supervisor does not require me to use mHealth.	.950
Voluntariness: 3. Although it might be helpful, using mHealth is certainly not compulsory in my job.	.928
Voluntariness: 1. My use of mHealth is voluntary	.890

Note. n=286; Eigenvalue for Component 1=2.608