# Ready-to-Hand: An Investigation of the Effects of Smartphone Technology Characteristics on Nurses' Perceived Usefulness and Attitudes towards using Smartphones for Work

Ian Chaves

Submitted to the Faculty of Extension

University of Alberta

In partial fulfillment of the requirements for the degree of

Master of Arts in Communications and Technology

August 18, 2015

**Acknowledgements**

I would like to thank my project supervisor, Dr. Gordon Gow, for his support and mentorship during this capping project and though out the MACT program…

I would like to express my gratitude to Tracy C., How L., and Gillian L. – thank you for being my survey testers. My next task is to have you as wine testers…

I would like to acknowledge the support of the College and Association of Registered Nurses of Alberta. Your support of research projects like this is invaluable to the discovery of new nursing knowledge and innovations…

To my MACT classmates in cohorts 2010 and 2011… if the medium is the message, then I should have written this with a sky-writing plane because the sky's the limit for you. Thank you for the barrel rolls, the panoramic view, your support during the turbulence, and the memories I won't soon forget – I'm looking forward to finally landing…

To all nurses… this project is rooted in my strong conviction towards the importance of nurses as experts in care. For all that you do, whether earnestly recognized or left humbly unnoticed, your work makes a difference in the quality of life of those you touch – you are everyday heroes…

To my brother… your courage and fortitude has been nothing short of an inspiration to me. I am proud of what you've accomplished and I will always be there to support you…

To my parents… your unwavering support of my life goals is the reason I am able to walk across the graduation stage (again) and sign my name with the initials of a proud MACT graduate. Most grown men don't tell their parents enough how much they care for them, so I hope to atone for it by letting it echo on this page – I love you both dearly.

## Abstract

As smartphone ownership increases, more nurses are beginning to use them in their workplaces. Historically, the uptake of information and communication technologies (ICTs) by nurses in their workplaces has been slow. However, with the widespread personal ownership of smartphones, a timely opportunity for smartphones to be more readily accepted by nurses presents. Previous research has shown that nurses' attitudes towards using smartphones for work are directly related to how they perceive their usefulness. However, little is understood about what influences these perceptions. To address this evidence gap, a prospective cross-sectional survey study was conducted to investigate the effects of smartphone technology characteristics on nurses' perceived usefulness and attitudes towards using smartphones for work. Using an integrated research model, composed of technology acceptance model (TAM) and task-technology fit model (TTF) constructs, a randomized sample of Registered Nurses in Alberta, Canada, was surveyed. Using multiple regression analysis, their responses were compiled and various hypotheses were tested. The results showed that: (1) nurses' perceived usefulness and views toward portability of smartphones had a significant effect on their attitudes towards using smartphones for work, and (2) nurses' views towards the portability and decision-support of smartphones had significant effects on their perceived usefulness of smartphones for work. These findings provide practical insights for nurse leaders and decision-makers to optimize the system design, policy, and implementation of smartphones so that nurses may more readily accept smartphones as a clinical tool.

***Keywords***: nurses, nursing informatics, smartphones, technology acceptance

## Table of Contents

**Table of Figures**

## Table of Tables

## Introduction

Amid nursing workforce shortages and increasing demands for healthcare services, healthcare leaders are under more pressure to find innovative ways to support nursing care without compromising patient safety and quality of care. As a result, they are exploring various strategies, including the appropriate application of information and communication technologies (ICTs) to support the knowledge work of nurses. Historically, nurses' acceptance of ICTs has been slow; however, the mainstream growth of ICTs may present a new opportunity to accelerate the acceptance of ICTs by nurses in their workplaces. The smartphone – a wireless information and communication device connected to online networks with advanced computing power – is becoming the mostly widely accepted and used handheld ICT device. At present, more than two thirds of Americans reportedly own a smartphone (Pew Research Centre, 2015). The most popular features used by smartphone owners include text-messaging, Internet use, voice/video calls, email, social networking, video, and music (Pew Research Centre, 2015). With smartphone ownership almost doubling since 2011 (Pew Research Center, 2015), we are now beginning to see more nurses utilize their smartphones in the clinical workplace (Moore and Jayewardene, 2014). However, we have little documented evidence explaining why nurses choose to use smartphones for work. What influences nurses' attitudes towards using smartphones for work? What are the characteristics of smartphones that influence nurses to use smartphones?

The purpose of this study is to examine how the technology characteristics of smartphones affect nurses' attitudes towards using smartphones at work. In doing so, the findings of this study are intended to help decision-makers, educators, and policy-makers in optimizing the design and implementation of smartphone systems for nurses to more readily accept smartphones in their workplaces. Prior to discussing the results of a literature review elucidating the current evidence pertaining to nurses' acceptance of smartphones, further background about the use of ICTs by nurses is presented.

**Nurse Knowledge Work and ICTs**

Registered Nurses (RNs) are a key professional group in healthcare because of their expert knowledge and skill in providing and coordinating patient care (CARNA, 2011). In information-rich healthcare environments, healthcare organizations are increasingly valuing the intellectual capital of nurses (how much nurses know about their care) and are seeking tools to support nursing knowledge work (Simpson 2007). Further to this need, nurse administrators are also seeking ways to overcome growing resource challenges. Workforce data predicts that by 2020, the demand for patient care services will grossly outpace the supply of nurses and healthcare services (Canadian Nurses Association, 2013*)*. These difficult workforce demands create conflicts between nurses, the nursing tasks they are responsible for, and the healthcare environment they work in, resulting in suboptimal nursing performance and errors (Mihailidis, Krones, & Boger, 2006). With the nursing workforce faced with a greater scarcity of resources, nursing leaders are prioritizing strategies to support nursing intellectual capital, including the appropriate application of nursing information systems and ICTs.

Regardless of their clinical practice area, nurses must use informatics and technology to inform and support their practice (Mastrian & McGonigle, 2012). Within the nurses' workflows, they are confronted with vast amounts of information. But for this information to beneficial, it must be easily accessible and packaged in a way that nurses are able to find the necessary information quickly and with minimal amounts of difficulty (Hardiker, 2012). ICTs have been touted as a key solution to improve nurse performance and help reduce clinical errors by providing timely access to patient and clinical information. Clinical decision support systems have been shown to improve clinical practice more effectively than manual systems, and to increase the utilization of evidence-based practice by nurses (Bassendowski et al., 2011; Doran et al., 2007; Honeybourne, Sutton, & Ward, 2006; Hsiao & Chen, 2012; Lu, Xiao, Sears, & Jacko, 2005; Mihailidis, Krones, & Boger, 2006; Morris & Maynard, 2010; Tapper, Quinn, & Brown, 2012; Thompson, 2005). For example, in one study, nurses reported that mobile nurse information systems had improved message exchange among health care professionals, facilitated patient communication, increased efficiency of patient care duties, increased the professional image of nursing, and improved overall performance in nursing practice (Hsiao & Chen, 2012). Because of the potential for increasing the quality of clinical care and the efficiency of care delivery, nursing administrators are actively seeking ways to transform healthcare delivery with the appropriate applications of ICT.

**Nurses and Early ICTs**

By supporting nurses with knowledge tools, nurses are able to provide knowledge-based care through (1) point-of-care and distance learning evidence-based practice, and (2) patient-focused care through patient-centered IT systems (e.g. electronic medical records, clinical information systems, and computerized physician ordering entry) (Simpson, 2007). While the clinical and practice benefits are appreciable, nurses have initially been reluctant to use ICTs at work. In 2003, Estabrooks et al. examined how nurses used online information in their workplaces (one of the first studies about nurses and ICTs). Their results indicated that, while nurses often used the Internet at home, they were less likely to use the Internet as a tool at work, and did so comparably less than any other professional group in healthcare. In this study, nurses cited a lack of trust in the information they would find, a lack of confidence in their computer skills, deficient computer access at work, and difficulties accessing computers due to their clinical workloads as reasons for their hesitancy to utilize ICTs in their workplace.

Since this study, follow-up research has shown similar findings. In a 2008 Australian study, 86% of nurses reported using computers in the workplace, but fewer than 25% of nurses stated feeling very confident using software applications (Eley et al.). In the same study, over 50% the nurses not working in administrative roles reported having insufficient sole access to computers at work compared to 80% of nurses in advanced clinical or administrative roles who reported using computers regularly. In addition to lacking access to computers, direct care nurses also reported having difficulty in finding time to regularly read evidence-based practice due to the burden of their clinical workloads (McKnight, 2006).

At the time these studies were conducted, ICTs were mainly fixed and stationary. This lack of portability acted as a significant barrier for nurses to use ICTs considering that the nature of nursing work tends to be highly mobile (McKnight, 2006). This illustrates how a lack of ICT mobility affected the early acceptance of ICTs, and points to the importance of usability as a determiner of end-user acceptance.

**Emergence of Mobile ICTs**

Since the early introduction of ICTs for nurses, there has been a steady increase in the prevalence of assistive computing devices in their workplaces (Marasovic et al., 1997, as cited by Mihailidis, Krones, & Boger, 2006), along with an exploding growth of ICT ownership in the consumer market (Pew Research Centre, 2015). Parallel to this increase in ICT exposure, specific demographic cohorts of nurses have reported a greater self-efficacy with ICTs. Eley et al. (2008) found that younger nurses reported being more confident and experienced in using ICTs. Thus, the increased growth of ICTs has likely contributed to an increase in the self-efficacy of nurses to use ICTs. This suggests that a larger fraction of the nursing workforce had grown to become ICT-ready.

Along with the increased utilization of computing technologies, computing technologies themselves have evolved - ICTs have become more mobile and possess the capacity to connect to online networks. Several studies investigating the experience of nurses using mobile ICTs found that nurses valued the portability of these devices because they were more useful in their clinical workflow (Bassendowski et al., 2011; Doran et al., 2010; Johansson, Petersson, & Nilsson, 2011; Lee, 2006; Morris & Maynard, 2010; Tapper, Quinn, & Brown, 2012). However, the same studies also showed that slow connection rates, difficulty in accessing connections, unreliable connections, and fear of losing devices negatively impacted nurses' views towards using mobile ICTs (Morris & Maynard, 2010; Tapper, Quinn, & Brown, 2012). The perceived benefits and barriers to using mobile ICTs illustrate the importance of aligning technology characteristics to the workflow and needs of nurse end-users.

Thus far, the most studied mobile ICT has been the personal digital assistant (PDA), and the evidence from PDA research provides further observations about the technology characteristics of ICTs that nurses are seeking.

**Nurses and Personal Digital Assistants**

PDAs are handheld computers that can be used as a reference tool to obtain evidence and guidance on clinical decisions, drug calculations, and clinical decision support (Divall, Camosso-Stefinovic, & Baker, 2013). Multiple studies have been conducted to explore nurses' experiences and attitudes towards using PDAs for work (Bassendowski et al., 2011; DiPietro et al., 2008; Doran et al., 2010; Doran et al., 2007; Honeybourne, Sutton, & Ward, 2006; Johansson, Petersson, & Nilsson, 2011; Morris & Maynard, 2010; Lee, 2006; Tapper, Quinn, & Brown, 2012). In many of these studies, nurses reported PDAs as being useful to access clinical and patient information. Notwithstanding, they also reported several barriers to using PDAs, including a lack of device usability and network connection reliability. To date, PDAs have been the dominant focus of mobile ICT studies and compose the greater part of research pertaining to nurses' clinical experiences with mobile ICTs. Continued PDA research, however, is unlikely. Due to the pace of technological development, timely evaluation of PDAs has not been possible (Divall, Camosso-Stefinovic, and Baker, 2013), and more advanced technologies have now replaced PDAs. A 2003 survey revealed that only 18% of nurses reported owning a PDA (Featherly & Beusekom, 2004). Since that survey, smartphones has replaced PDAs and have shown greater widespread acceptance.

**The Emergence of Smartphones**

Unlike PDAs, Smartphones are capable of integrating Internet connectivity, voice calling, text-messaging, and computing, further augmented with greater processing speeds. These features allow users to access multimedia digital content and support one-to-one and/or one-to-many communications. Since 2011, smartphone ownership in the

United States has grown from 35% to 64%, and many smartphone owners reported that these devices are their key access point to the online world (Pew Research Centre, 2015). With the substantial growth of smartphone ownership in the consumer market, more nurses are bringing and using their own smartphones in their workplaces (Moore & Jayewardene, 2014). This “bring-your-own-device” phenomenon has resulted in some organizations seeking ways to best support this practice via policy and infrastructure (Moyer, 2014).

With increased smartphone ownership, we expect to see more smartphones being used by nurses in their workplaces. Correspondingly, we should expect to find more research investigating the use of smartphones by nurses and the factors influencing their decisions to use them. To shed light on the evidence pertaining to nurses’ acceptance of smartphones a literature review was conducted. The results of this literature review are discussed in the next section, evidence gaps are identified, and the research question for this study is proposed.

# Literature Review

To conduct the literature review, the following healthcare databases were searched: CINAHL, Medline, Academic Search Premier, Healthstar, and the Cochrane Research Database. The initial search terms used included “smartphones” and “nurs*”, and the results were limited to peer-reviewed journals, studies in the English language, and studies published between 2003 and 2015. The abstracts of the search results were reviewed and all primary research studies investigating nurse views and acceptance of smartphones were included in the review.  The search was then expanded to include the terms “handheld computers”, “information and communication technology”, and “technology acceptance model” to find nurse technology acceptance studies of devices similar to smartphones, as well as additional evidence to inform the theoretical approach and background for this study. Based on the search results, two main topics were identified and are discussed further: (1) technology acceptance theories, and (2) nursing smartphone studies.

## Technology Acceptance Theories

Technology acceptance has been a significant area of study for information technology (IT) researchers as they sought ways to optimize the use of ICTs by end users. In early IT research, explaining technology acceptance has been a challenge due to a lack of high-quality measures for key determinants of technology acceptance (Davis, 1985; Moore & Benbasat, 1991). As a result, numerous theories have been proposed to try to explain technology acceptance. In studies investigating nursing smartphone acceptance (or like devices), the Technology Acceptance Model (TAM) and the Task-Technology Fit theory (TTF) have been commonly cited.

**Technology Acceptance Model.** In 1985, Davis proposed the technology acceptance model (TAM) to explain the variance in technology acceptance among users. Davis derived TAM from the foundations of other theories: self-efficacy theory, cost-benefit paradigms, adoption of innovation theory, and channel of disposition theory. He suggested that key constructs of these theories converged to support the conceptual and empirical distinction of two main constructs: usefulness and ease of use. *Usefulness*, or perceived usefulness (PU), is defined as a user's belief in the extent a new application or system will help them perform their jobs better. *Ease of use*, or perceived ease of use (PEOU), is a user's belief in the extent of effort to use the new system is worth the performance benefits of the new system. From these two constructs, Davis theorized that a user's attitude towards a new system (ATT) is related to his/her PU and PEOU of that system. In turn, ATT influences the user's behavioural intent (BI) to use the system. While testing TAM, Davis found these constructs showed a high-level of validity and reliability in predicting and explaining the end-user variance in technology acceptance. Numerous studies have since used TAM as a theoretical frame and have demonstrated similar reliability in predicting and explaining the variance in user intentions and behaviors for various ICTs (Chen, Park, & Putzer, 2010; Park & Chen, 2007; Putzer & Park, 2007; Venkatesh & Davis, 2000; Moore & Benbasat, 1991).

Researchers have lauded the reliability and parsimonious nature of TAM, which is likely why TAM has been so commonly used to study technology acceptance. In a systematic review of factors influencing the adoption of ICTs, Gagnon et al. (2012) found that TAM constructs were the most widely cited. Within the context of healthcare, TAM has been used to investigate nurses' acceptance of various ICT applications including telemedicine (Kowitlawakul, 2011), clinical information systems (Lu, Hsiao, & Chen, 2012), and mobile information technology in homecare (Zhang, Cocosila, & Archer, 2010).

While the reliability of TAM to explain technology acceptance in terms of PU, PEOU, ATT, and BI has been validated, TAM does not come without its criticisms or limitations. Benbasat and Barki (2007) assert that TAM research has been unable to shed light on what specifically makes a system useful. Rather than explaining the effects of external variables on technology acceptance, TAM posits that these variables are mediated by PU and PEOU (Venkatesh & Davis, 2000), revealing little about the influence of additional sub-factors. Other researchers have criticized TAM for not considering the social influence on technology acceptance (Benbasat & Barki 2007; Wu & Wu, 2007). Collectively, these criticisms indicate that TAM lacks the constructs to provide practical information to researchers about how systems should be implemented, and in what ways these systems are impacted by social context. This lack of praxis has lead to the introductions of modified TAM models, which extend pre-existing TAM constructs or integrate constructs from other theoretical model (Chau & Hu, 2001; Kwon & Zmud, 1987; Moore & Benbasat, 1991; Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh & Davis, 2000; Yi, Jackson, Park, & Probst, 2006). While these studies have provided new insights into what may influence PU and PEOU, PU and PEOU remain the most studied concepts in TAM research (Venkatesh & Davis, 2000; Moore & Benbasat, 1991). With respect to examining nurses' acceptance of smartphones, several studies used TAM to underpin their research and these studies will be discussed if further detail later in this section.

**Technology Task-Fit Model.** The Technology Task-Fit Model (TTF) has also been used a theoretical model to explain the acceptance of ICTs. TTF posits that, "for IT to have a positive impact on individual performance, the technology used must appropriately fit the task it supports (Goodhue, 1995, as cited by Hsiao & Chen, 2012, p. 266)". According to Goodhue (1998):

> "The heart of the task-technology fit model is the assumption that information systems give value by being instrumental in some task or collection of tasks and that users will reflect this in their evaluations of the systems. Thus, the strongest link between information systems and performance impacts will be due to a correspondence between task needs and system functionality (task-technology fit) (p. 107)."

Unlike TAM, TTF illuminates the influence of task and technology characteristics, which provides findings with more specific practical application. Three main components are identified in TTF: (1) task characteristics – the task needs of the user; (2) technology characteristics – the specific characteristics of the information systems, and (3) task-technology fit – the correspondence between task needs and system functionality. A number of validation studies for TTF have shown consistent patterns of relationship between task-technology fit, technology characteristics, and task characteristics (Dishaw & Strong, 1998; Goodhue, 1998; Goodhue, 1995; Goodhue, Thompson, & Goodhue, 1995; Lee, Cheng, & Cheng, 2007; Rippen et al., 2013).

TTF is a relatively novel theory for technology acceptance, so no studies were found using TTF to examine nurses' acceptance of smartphones. However, a study conducted by Hsiao & Chen (2012) used TTF to examine the factors affecting the fit between nursing tasks and mobile nursing information systems. In this cross-sectional prospective study, their findings showed that the support functions of a mobile nursing information system had a positive effect on information acquisition by nurses, and that using the mobile nursing information system had a positive effect on nursing performance. These findings demonstrate the relationship between the characteristics of a mobile information system with the nature of a nurse's tasks.

To leverage each of TAM and TTF's explanatory lenses to examine the attitudes towards technologies and the influence of technology and task characteristics, Dishaw & Strong (1998) proposed and validated an integrated TAM/TTF model. In this model, they posited that task and technology characteristics affected perceived usefulness and ease of use. This integrated model has since been used and validated by Yen et al. (2010) to investigate the determinants of users' intentions to use wireless technology in organizations, and by Lee, Cheng, and Cheng (2007) to examine the use of mobile commerce in the insurance industry.

An integrated TAM-TTF model may provide further theoretical insight about the influence of smartphone technology characteristics on the acceptance of smartphones by nurses. In the methodology chapter of this report, the use of an integrated TAM-TTF model for this study is discussed in greater detail.

**Smartphone Acceptance by Nurses**

Further to the evidence informing the theoretical approach for this study, the literature review revealed a number of articles providing evidence about nurses' views and acceptance of smartphones.

The first article for discussion is a survey study conducted by Moore and Jayewardene (2014) who investigated how nurses and physicians used smartphones in a hospital in the United Kingdom. Their results showed that 58% of nurses and 81% of physicians used smartphones at work. Of these users, 72% of nurses and 83% of physicians used smartphones to access textbooks a formularies, while 61% of nurses and 73% of physicians, used smartphones as calculators and clinical decision tools. When asked about the perceived advantages/disadvantages of using smartphone applications, the highest percentage of nurse respondents agreed that smartphones "improve access to information (65%)", followed by "improve decision making (45%)", and "improve efficiency (40%)". This study provided a quantitative description of the overall use of smartphones by RNs, and illuminated how they used smartphones for their clinical information needs. However, this study used a small convenient sample of nurses (n=82), limiting its statistical power, and did not provide any evidence about what influenced the nurses' attitudes towards smartphones.

In 2014, Nagler et al. added further evidence about healthcare team members' view of the benefits using smartphones for patient care. They conducted a pre-and-post-survey study of an implementation of smartphones in a hospital in the United States (US). There were a total of sixty-four nurses who participated in the implementation. However, the number of these nurses who responded to their surveys was not reported. They found that clinician views towards using smartphones slightly decreased after implementation, suggesting that the implemented smartphone system fell short of the nurses' expectations. The authors suggested that this decrease might have been due to the short time period of study (three months), which limited the amount of user-training clinicians' had and the time benefits that could be observed. However, there were two survey items where nurses demonstrated an increased positive response after the implementation of smartphones: "the device will improve patient care (4.05 to 5.27; $p= < 0.000$)" and "the device will improve patient safety (4.52 to 5.44; $p= <0.000$)". Though the clinicians' views towards smartphone were lower after implementation, respondents still rated the use of smartphones positively when compared to the previous pager system that they had been using. This study, the only one found using a pre-post implementation design, elucidated that nurses' views towards smartphones can change after implementation.

The studies by Moore and Jayewardene (2014) and Nagler et al. (2014) provided initial evidence about how nurses view smartphones. However, they did not directly examine the factors affecting the acceptance of smartphones by nurses. Fortunately, a collection of studies conducted by Park and Chen (2007), Chen, Park, and Putzer (2010), and Putzer and Park (2010) quantitatively examined various factors affecting the acceptance of smartphones by nurses and other healthcare professionals.

Park and Chen (2007) conducted the first of these studies. Using a convenience sample of nurses and physicians working in a network of hospitals in the US Midwest, they examined how healthcare professionals' motivations for adopting smartphones were affected. To form their research model, they integrated constructs from three different technology acceptance theories: (1) TAM, (2) Self-efficacy, and (3) the Innovation Diffusion Theory (IDT). They proposed fourteen hypotheses and tested the relationships between the key constructs from these theories. These constructs included behavioural intent to use smartphone (BI), attitude towards smartphones (ATT), perceived usefulness of smartphones (PU), and perceived ease of smartphone (PEOU), self-efficacy (SE), compatibility (COMP), observability (OBS), trialability (TRI), task relevance (TR), individual factors (IND), organizational factors (ORG), and environmental factors (ENV). Using structural equation modeling (SEM), their results showed nine of their hypotheses to be statistically significant. Specifically, ATT had an effect on BI; PU had an effect on BI; PEOU had an effect on PU; PEOU had effect on ATT; SE had an effect on PEOU; SE had an effect on BI; OBS had an effect on AT; and ORG had an effect on AT.

These results confirmed that BI was significantly influenced by a nurse's perceived usefulness of smartphones and their attitude towards smartphones. Interestingly, while both PU and PEOU were found to have a positive effect on a nurse's attitude towards smartphones, PU had a much stronger influence on a nurse's attitude towards smartphones. This suggests that nurses may choose to overcome negative perceptions of a smartphone's ease of use to a certain extent, if they believe there is valuable performance advantage in using smartphones in their work. They also found that PU was positively affected by PEOU, and that PEOU was influenced by self-efficacy. These findings illustrate that nurses who are more confident in their skills to use computing technologies are more likely to perceive the usefulness in using smartphones. Studies have shown that many nurses lacked confidence in their computer skills to use ICT (Eley et al., 2008; Estabrooks et al., 2003); however, there is recent evidence showing that nurses are entering the workforce with more experience with computing technologies (Eley et al., 2008).

Following from Park & Chen (2007), a similar study was conducted in 2010. Chen, Park, and Putzer (2010), who used a similar theoretical model, also investigated the factors that influenced the acceptance of smartphone among healthcare professionals. Their convenience sample was composed of nurses and physicians from one hospital in the US Midwest and one hospital in Taiwan. Similar to the initial study by Park & Chen (2007), Chen, Park, & Puzter gathered survey data to test various relational hypotheses among the constructs of their integrated model using SEM. They tested 15 hypotheses and five of them were found to be statistically significant. Their findings indicate that (1) ATT influences BI; (2) PU influences ATT; (3) Self-efficacy (SE) influences BI; (4) compatibility influences PU; and task alignment influences ATT.

In comparing these findings to the original study by Park & Chen (2007), there are a couple notable observations. Firstly, both studies confirmed strong effects between ATT and BI, and PU and ATT. This further supports TAM’s explanatory power for the variance in nurses’ attitudes towards smartphones use, and the significant relationships between PU, ATT, and BI. Importantly, both studies confirmed the significant effect of PU on ATT. Secondly, while Park and Chen (2007) and Chen, Park, and Putzer (2010) demonstrated similar results in the correlation between TAM constructs, they showed differing results in the effects of the IDT attributes and self-efficacy. With respect to these factors, Park and Chen (2007) found nine hypotheses that were statistically significant, while Chen, Park, & Putzer (2010) only confirmed five significant hypotheses. The difference in results between these studies suggests the need for further investigations to make more reliable conclusions about the effects of IDT attributes and self-efficacy on ATT, PU, and PEOU.

Also in 2010, Putzer and Park conducted a study examining the effects of the IDT attributes to smartphone adoption among nurses. Unlike the previous two studies, this study solely focused on the IDT factors and their effects on ATT. They proposed seven hypotheses between the IDT factors and ATT, and analyzed them using SEM. Of these seven hypotheses, five hypotheses were supported: (1) observability influences ATT; (2) compatibility influences ATT; (3) job relevance influences ATT; (4) environment factors (ENV) influence ATT; and (5) ENV influence ATT. Like the previous studies discussed, this study demonstrated the effects of IDT directly on nurses' attitudes towards smartphones. Some researchers believe that using IDT compliments the use of TAM by further illuminating how social processes influence the formation of attitudes towards a technology (Wu & Wu, 2006).

When comparing Putzer and Park (2010) to the previous two studies, a common finding was noted. Putzer and Park (2010) found that the observability of smartphones had a significant influence on the nurse's attitude towards smartphones, which was similar to what was found by Park and Chen (2007). In the context of this current study, it is important to note that the observability of smartphones has likely changed due to widespread smartphone uptake (Pew Research Centre, 2011) since these two preceding studies were conducted. Thus, it can be deduced that nurses' attitudes towards using smartphones for work have also likely changed.

## Evidence Gaps in Nursing Smartphone Acceptance

This literature review revealed that the current evidence on smartphone acceptance by nurses either quantified nurses' views of smartphones or measured the effects of various factors on their acceptance of smartphones. Both Moore &

Jayewardene (2014) and Nagler et al. (2014) elucidated how nurses viewed the use of smartphones for work. Additionally, Nagler et al.'s (2014) study further illustrated that these views may change over time. However, their study did not specifically investigate the factors that influence these views during implementation. Thus, an evidence gap exists about what is currently known about the factors that influence nurses' views of using smartphones for work.

Further to these studies quantifying the views of nurses towards using smartphones, a series of TAM smartphone studies (Chen, Park, & Putzer, 2010; Park & Chen, 2007; Putzer & Park, 2010) confirmed that the variance in nurses' attitudes towards smartphones has been consistently and reliably explained by the effect of nurses' perceived usefulness of smartphones. While these findings reinforce TAM's ability to predict smartphone acceptance via PU, they did not uncover the practical characteristics of smartphone systems that affect the perceived usefulness and acceptance of smartphones by nurses. Currently, there is a lack of knowledge about nurses' smartphone acceptance that can be practically applied to optimize the design, implementation, and policy towards smartphone systems for nurses. Thus, understanding what makes a smartphone useful to nurses remains an evidence gap needing further research.

These nursing smartphone acceptance studies point to a further need to understand the specific factors that affect the acceptance of smartphone of nurses. By uncovering these factors, further knowledge would be gained to inform the practical design and implementations of smartphone systems to optimize their acceptance by nurses. To conduct such a study, the technology characteristics of smartphones would need to be identified, and to date, no known smartphone studies have done so.

Fortunately, previous studies of nurses' use of PDAs offer insights that can be used to conceptualize technology characteristics of smartphones. Mihailidis, Krones, and Boger (2006) showed that device portability, mechanism for data entry, communication capability and modes, information accessibility, decision-making support, alerts and reminders, and medication safety were functions and features nurses found useful. Similarly, DiPietro et al. (2008) found that hardware characteristics, software ease-of-use, software content, and network connectivity were important features for designing a PDA system to support use of evidence-based practice. Thus, these features can be used to form the technology characteristics of smartphones, and examine how they influence nurses' perceived usefulness and attitudes towards smartphones.

**Research Question Proposal**

Based on the evidence gap identified in this literature review, there is an opportunity to discover practical insights that can be used to optimize the acceptance of smartphones by nurses. Such an investigation would look to examine the effects of smartphone technology characteristics on nurses' perceived usefulness and attitudes towards using smartphones at work. Ergo, the proposed research question for this study is:

> *What are the effects of smartphone technology characteristics on nurses' perceived usefulness and attitudes of using smartphones for work?*

To approach this question, a research framework has been designed, which includes the use of a TAM-TTF theoretical model, the development of a survey instrument, and the identification of procedures for data collection. This methodological framework is presented and discussed in greater detail in the next chapter.

## Research Design and Methodology

A review of the literature showed a need to uncover more practical insights about the technology characters affecting smartphone acceptance by nurses. In this chapter, the research framework designed to address the proposed research question is discussed in greater detail. This includes further discussions about the paradigm and theoretical models used, the research hypotheses being proposed, and the procedures used to conduct this study (e.g. methods of analysis, survey instrument, eligibility criteria, sampling, and ethical considerations).

### Research Question

*What are the effects of smartphone technology characteristics on nurses' perceived usefulness and attitudes towards using smartphones for work?*

### Research Framework

**Paradigm.** The purpose of this study is to investigate the effects between smartphone technology characteristics on nurses' perceived usefulness and attitudes towards using smartphones for work. This type of investigation falls within the discovery research paradigm, which Merrigan, Huston, and Johnston (2012) described as "knowledge testable through logical and empirical methods, and where by using these rational means, researchers are able to determine what is theoretically connected (p. 3)." Several investigations of nurse attitudes towards smartphones (Chen, Park, & Putzer, 2010; Park & Chen, 2007; Putzer & Park, 2010) have used a discovery paradigm to determine the correlation of factors thought to influence the acceptance of smartphones by nurses. Findings from these studies have demonstrated statistically significant results, confirming that the majority of variance of the acceptance of smartphones by nurses is explained by nurses' perceived usefulness towards smartphones.

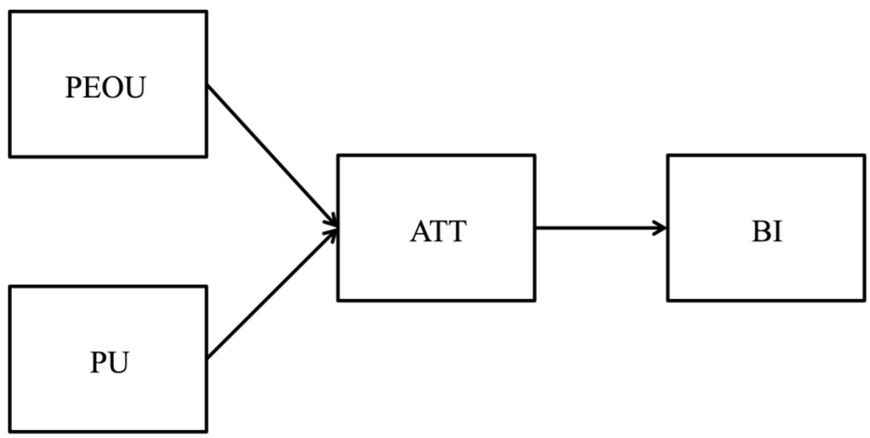
Further to nurses' beliefs towards smartphones, Hsiao and Chen's (2012) investigation of mobile information devices and task-technology fit for nurses is also considered discovery research. Their quantitative study confirmed a significant relationship between nursing task characteristics, mobile information device technology characteristics, and task-technology fit, which in turn affected the nurses' utilization of mobile computing devices.

Building upon this body of discovery research, this current study deployed similar methods of data collection and statistical analysis to logically and empirically test the correlations between the research variables. These methods will be discussed later in this section and in the *Data Analysis and Results* chapter.

**Theoretical model.** Under a discovery paradigm, explanatory and predictive claims are used to define the relationships observed between one set of data and another (Merrigan, Huston, & Johnston, 2012). Constructs from two technology acceptance theories – the technology acceptance model (TAM) and the Task-Technology Fit theory (TTF) – were used to structure the predictive claims between the key constructs in this study. These predictive claims underpinned the research hypotheses for this study. Prior to discussing the hypotheses for this study, it will be important to explore the core constructs underpinning this study's research framework.

***Technology Acceptance Model.*** Davis (1985) hypothesized that technology users will have a higher behavioural intent to use an information technology (BI), if they have a positive attitude towards the technology (ATT). In turn, users' attitudes towards a technology are influenced by their beliefs in how that technology will improve their job performance (PU), and the extent of which the use of the technology is relatively free of effort (PEOU). Figure 1 illustrates the theoretical relationships among BI, ATT, PEOU, and PU in TAM.

*Figure 1. The Technology Acceptance Model*




Numerous studies have used TAM as a theoretical foundation and have demonstrated its consistency and validity in explaining the majority of covariance in technology user acceptance (Chen et al., 2010; Kowitlawakul, 2011; Lu, Hsiao, & Chen, 2012; Park & Chen, 2007; Putzer & Park, 2010; Venkatesh & Davis, 2000; Wu & Wu, 2005). Many TAM studies have confirmed PU as a significant variable in explaining the variance of ATT (Kowitlawakul, 2011; Park & Chen, 2007; Venkatesh & Davis, 2000; Wu & Wu, 2005). PEOU, on the other hand, has shown to have a lesser effect on ATT (Davis, 1985; Park & Chen, 2007; Venkatesh & Davis, 2000).

***Task-Technology Fit Theory.*** The task-technology fit (TTF) theory is an evolving theory being used to further explain technology acceptance (Yen, Wu, Cheng,

& Huang, 2010). Based on utilization and task-technology research streams, Goodhue (1995) proposed TTF to explain the relationship between information systems and individual performance. The main constructs for TTF are:

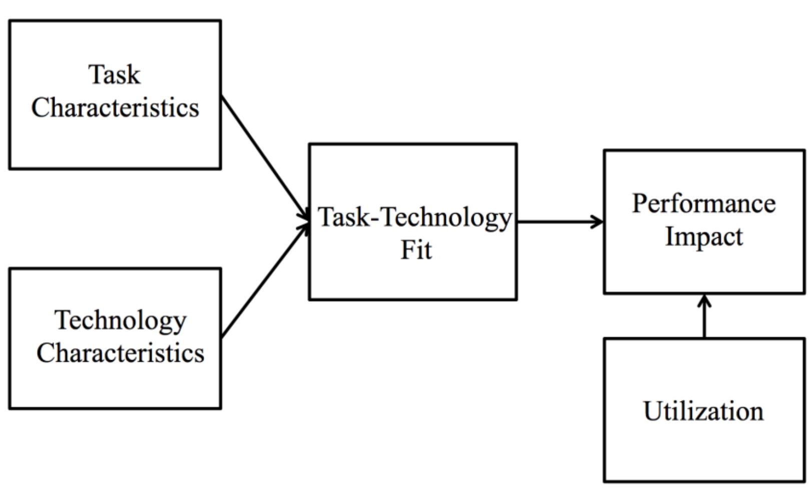
*Technology Characteristics (TECH)*: the characteristics and supports of the technology used by the user to perform their tasks;

*Task Characteristics (TASK)*: the nature of the actions carried out by individuals to turn inputs into outputs;

*Task-Technology Fit (TTF)*: the degree to which a technology assists a user to carry out his or her tasks.

Based these constructs, TTF posits that the user will accept a technology if the technology's characteristics and supports (TECH) align to the task performed by the user (TASK). Thus, the higher the degree the technology supports the user to perform his/her tasks (TTF), the greater the likelihood they will utilize the technology. Figure 2 illustrates the Task-technology Fit Model.

*Figure 2: The Task-Technology Fit Model*



***Integrated TAM-TTF model.*** TAM and TTF both identify a relationship between utilization and usefulness. Goodhue (1995) suggested that task-technology fit influences technology utilization, which he believes indicates the user's perceived usefulness of the technology – a core construct of TAM. Thus, perceived usefulness is what allows for the integration of the TTF and TAM concepts. In 1999, Dishaw and Strong merged the concepts of user-beliefs and task and technology fit, forming an integrated TAM-TTF model. In this integrated TAM-TTF model, a user's beliefs towards a technology are predicted to be influenced by the characteristics of the tasks, the characteristics of the technology, and the nature of the task-technology fit. Using integrated models has allowed researchers to explore the relationships between TAM's belief constructs (ATT, PU, and PEOU) and TTF's technology and task characteristics (Yen et al., 2010), which potentially illuminates more specific practical insights**.**

For this current study, an integrated TAM-TTF model was used as a framework to explore how smartphone technology characteristics influence nurses' perceived usefulness and attitudes towards using smartphones at work. However, unlike previous TAM-TFF studies, the findings from this study aim to quantify the effects of practical constructs to better inform the implementation and design of smartphone technologies so nurses more readily accept them.

## Proposed Research Models for this Study

Several adaptations of TAM-TTF models were used to develop the TAM-TTF research model for this current study. When considering proposing a modified TAM-TTF research model, it is important to realize the difficulty in examining every construct of an integrated acceptance model in a single study. Goodhue (1995) recognized that the initial conceptualization of TTF was too large to be tested in one study. Furthermore, based on Cohen's (1992) recommendation for power analysis, the greater the number of variables in a regression study, the larger the sample size needed. As a result, decisions were made to control the size of the research model for this study to ensure its operational feasibility.

In forming the research model for this study, the approach used by Yen et al. (2010) provided useful insights. In their study investigating the determinants of users' intention to adopt wireless technology, their research model used the core TAM constructs (e.g. PU, and PEOU), but integrated them with a simplified TTF model to reduce the complexity of their study. Since the aim of this current study is to provide practical insights to help administrators optimize the design and implementation of smartphone systems to be accepted by nurses, the research model for this study will focus on the technology characteristics of smartphones, and, therefore, will not include TASK or TTF variables. This decision was made to ensure the research model remained manageable and the sample size required for this study remained achievable.

Another reason technology characteristics were focused on exclusively was due to the availability of evidence that could be used to define them. Previous studies of mobile nursing computing systems (Mihailidis, Krones, & Boger, 2006) and PDAs (Di Pietro et al., 2008; Doran et al., 2007; Lee, 2006) have identified common technology characteristics for mobile ICTs used by nurses. These characteristics included:

(1) Device portability (PORT): the ability to use smartphones in a mobile workflow;

(2) Documentation (DOC) - the ability to use smartphones to record work-related data;

(3) Information access (IA) - the ability to access information more readily;

(4) Decision support (DS) - the ability to process and interpret data to make clinical decisions;

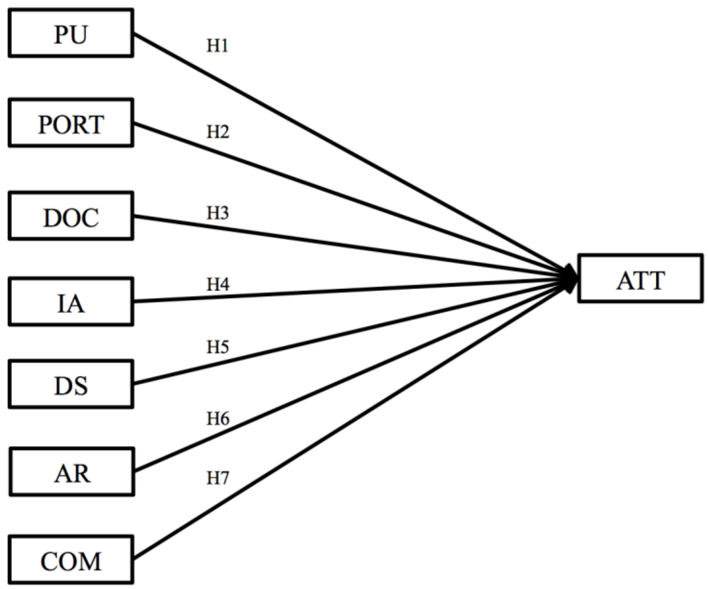
(5) Alert and reminders (AR) - the ability to use smartphones to alert and remind the user of clinical events;

(6) Communication (COM) - the ability to use smartphones to telecommunicate with other healthcare providers (e.g. texting and voice calls).

Goodhue (1995) indicated that the identification of technology factors for TTF is dependent on the technology itself. Since these six functions of mobile ICTs have been consistently identified in previous studies and have been reported by nurses as desirable functions, they were deemed appropriate to be used as the technology characteristics for the research model in this study. Subsequently, these technology characteristics formed the determiner variables for this study.

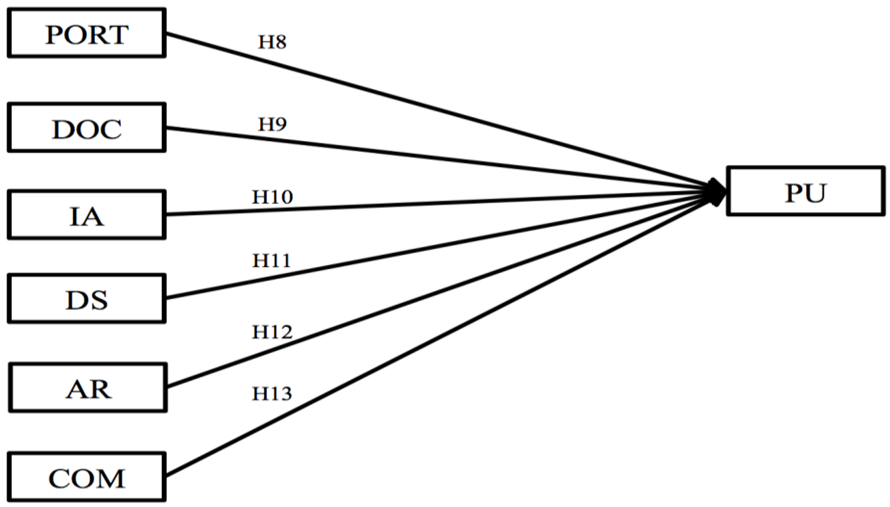
Of note, medication safety was also identified as a function sought by nurses in ICTs (Mihailidis, Krones, & Boger, 2006). However, in operationalizing these concepts and based on feedback from survey testers, the researcher assessed that medication safety functions fall under several constructs already identified (i.e. information access, decision-support, and alert and reminders). Thus, medication safety was not included as a separate characteristic; however, it was referenced in the survey tool as part of decision-support

*Figure 3: The TAM-TTF Research Model A*




While the technology characteristics identified previously will be used as determiner variables, ATT and PU will be used as outcome variables to illuminate how technology characteristics affect nurses' attitudes and perceived usefulness of smartphones for work. PEOU was not examined in this study in order to reduce the number of variables required for this study. This decision was also rationalized in that PEOU has shown to have less of a significant direct effect on nurses' attitudes towards smartphones than PU (Park & Chen, 2007).

*Figure 4: The TAM-TTF Research Model B*




**Research Hypotheses**

Figures 3 and 4 illustrate the adapted TAM-TTF models that will be used for this study and illustrates the various hypothesized relational paths among the technology characteristic variables and ATT and PU. It is important to distinguish that two research models were used for this study: one with ATT as the outcome variable, and one with PU as the outcome variable. Due to limitations in the statistical method deployed, the measurement of all variables in one model was not possible. Ideally, a single model would account for the proportion of variance of the technology characteristic variables, PU, and ATT. Unfortunately, such an approach requires the use of structural equation modeling (SEM), a method which could not be used due the researcher’s level of expertise with SEM and because of the extremely large sample size SEM demands (Vogt, Vogt, & Gardiner, 2014). Having to use two research models in this study means that the results will be limited in accounting for the all the variance that may occur when PU and ATT are modeled together. Regardless of this limitation, the proposed research models will still provide useful quantitative insights about the effects of technology characteristics on PU and ATT. Further limitations of using this approach will be discussed in the conclusion of this report.

The integration of TAM and technology characteristics formed the various research hypotheses for this study. The first hypothesis is based solely on the TAM constructs of PU and ATT. Like the previous study by Park and Chen (2007) that found a relationship between PU and ATT, this study will use PU as a determiner variable for ATT. The resulting hypothesis is:

**H1**: Perceived usefulness of a smartphone for work will have a significant effect on nurses' attitudes towards using smartphones for work (PU ➔ATT).

Further to the relationship between PU and ATT, the technology characteristics identified from previous PDA studies will form the various technology characteristics variables in this study. The technology characteristic variables included: (1) portability (PORT), (2) documentation (DOC), (3) information access (IA), (4) decision support (DS), (5) alerts and reminders (AR), and (6) communication (COM). These technology characteristic variables will be used as determiner variables for both ATT (Model A) and PU (Model B). For Model A, with ATT as the outcome variable, the resulting hypotheses are:

**H2**: Attitude towards smartphone portability will have a significant effect on a nurse's attitude towards using smartphones for work (PORT➔ATT);

**H3**: Attitude towards documentation on smartphones will have a significant effect on a nurse's attitude towards using smartphones for work (DOC➔ATT);

**H4:** Attitude towards information access on smartphones will have a significant effect on a nurse's attitude towards using smartphones for work (IA➔ATT);

**H5**: Attitude towards decision-support on smartphones will have a significant effect on a nurse's attitude towards using smartphones for work (DS➔ATT);

**H6**: Attitude towards alerts and reminders on smartphones will have a significant effect on a nurse's attitude towards using smartphones for work (AR➔ATT);

**H7**: Attitude towards communication on smartphones will have a significant effect on a nurse's attitude towards using smartphones for work (COM➔ATT).

For Model B, with PU as the outcome variable, the resulting hypotheses are:

**H8**: Attitude towards smartphone portability will have a significant effect on a nurse's perceived usefulness of smartphones for work (PORT ➔PU);

**H9**: Attitude towards documentation on smartphones will have a significant effect on a nurse's perceived usefulness of smartphones for work (DOC➔PU);

**H10**: Attitude towards information access on smartphones will have a significant effect on a nurse's perceived usefulness of smartphones for work (IA➔PU);

**H11**: Attitude towards decision-support on smartphones will have a significant effect on a nurse's perceived usefulness of smartphones for work (DS➔PU);

**H12**: Attitude towards alerts and reminders on smartphones will have a significant effect on a nurse's perceived usefulness of smartphones for work (AR➔PU);

**H13**: Attitude towards communication on smartphones will have a significant effect on a nurse's perceived usefulness of smartphones for work (COM➔PU).

To test these proposed hypotheses, data will be collected using a survey instrument and the correlations between the determiner and outcome variables will be analyzed using multiple regression. The method for analysis will be discussed in greater detail in the *Data Analysis and Results* section.

## Procedure

To operationalize this study, procedures were developed to explain how data would be collected, how the data would be analyzed, how the sampling was determined and conducted, and how ethical implications were considered.

**Survey instrument.** Survey research is one of the most important areas of measurement in applied social science (Fowler, 2001, as cited by Trochim & Donnelly, 2008) and more quantitative social science data has been collected through survey research than any other method (Vogt, Vogt, & Gardiner, 2014). Surveys are used to learn about the characteristics of individuals or groups, and to investigate how those characteristics are related to specifics issues, which include beliefs, opinions, attitudes, and emotions. Because the focus of this study was to examine nurses' attitudes, a cross-sectional questionnaire, which collects data at a single point of time and provides a snapshot of the phenomenon being studied (Merrigan, Huston, & Johnston, 2012), was used as the survey instrument for this study. One of the most utilized survey questionnaires to study technology acceptance was developed by Davis (1985). Since the introduction of TAM, many studies have used survey research methodology by modifying Davis' TAM survey tool (Chen, Park, & Putzer, 2010; Park & Chen, 2007; Putzer & Park, 2010).

A new 38-item survey instrument was developed for this study based on a combination of validated and novel survey items. The survey items for ATT and PU were originally conceived by Davis (1985), and have been adapted and validated for smartphone acceptance research by Chen, Park, & Putzer (2010), Park & Chen (2010), and Putzer and Park (2010). Thus, the ATT and PU survey items in these studies were used for the new survey instrument. New survey items had to be developed to measure the various technology characteristic variables proposed in the research model, as these constructs have not been previously measured in TAM research. As discussed prior, the survey items for the technology characteristic variables were based on ICT functions found in previous research that nurses identified as useful (DiPietro et al., 2008; Doran et al., 2007; Lee, 2006; Mihailidis, Krones, & Boger, 2006). Because the survey items for these variables are novel, further statistical testing was conducted to assess the reliability and validity of the all survey items of the instrument. Reliability and validating testing is discussed in further detail in the *Data Analysis and Results* chapter of this report.

For each survey item, a five-point Likert scale was used, consisting of a statement about the given variable and a scoring of 1 (strongly disagree) to 5 (strongly agree). The Likert scale, the most common question format in survey research, allows for scores on a survey item to be summed to get an overall assessment of that item and also provides specific information about component questions to allow for further reliability and validity testing of the instrument (Vogt, Vogt, & Gardiner, 2014). For this survey, respondents were asked to indicate the extent of which they agreed with statements about their views towards using smartphones for work (ATT), views towards the usefulness of smartphones for work (PU), and views towards various technology characteristics of smartphones. For each corresponding variable, survey items scores were averaged to allow for further statistical analysis and testing of the research hypotheses. For example, for ATT, the mean Likert scores for ATT1, ATT2, and ATT3 formed the final ATT value. Individual item scores were also used for instrument validation, which is discussed in the *Data Analysis and Results* chapter. A copy of the survey instrument used is included in Appendix E.

The survey instrument was initially piloted by three Registered Nurses to test the clarity of the content and functionality of the survey. Their narrative feedback was collected and the survey was edited accordingly. The final survey instrument was delivered electronically using an electronic survey service (FluidSurvey™), and remained open for a five-week period. Electronic surveys require fewer resources and are more convenient to deliver (Merrigan, Huston, & Johnston, 2012); however, they also have poorer response rates and may lead to response bias (Van Gesst & Johnson, 2011). Because of the limited resources available to conduct this study, delivery of hardcopy surveys was not possible. The limitations relating to the use of electronic survey delivery are discussed in further detail in the conclusion of this report.

**Regression analysis & hypothesis testing.** Null hypothesis testing allows researchers to statistically test the likelihood that the results achieved in a study are because of an actual relationship between variables, as opposed to by error or chance. During null hypothesis testing, each research hypothesis (also known as the alternate hypothesis) has a null hypothesis that predicts that the determiner variable has no effect on the outcome variable. During data analysis, statistical methods are used to determine whether the data from the sample allows the researcher to reject the null hypotheses and accept the alternate hypotheses to confirm that the determiner variable has a statistically significant effect on the outcome variable.

To perform the hypotheses testing, the data collected in the survey was analyzed using multiple regression analysis. Regression analysis is a statistical test that allows researchers to predict the unknown values of a dependent variable from the obtained independent variable, assuming that the variables are expected to correlate (Merrigan, Huston, & Johnston, 2012). The resulting value expresses the proportion of the variation in the outcome variable that can be directly explained by the variation in the determiner variable. In multiple regression analysis, the correlations of more than one determiner variable on an outcome variable are examined and accounted for, and the regression coefficient (B-value) and the p-values are calculated for each pair of variables of each research hypothesis.

B-value describes the direction of the relationship between given variables. The more positive the B-value, the greater the effect of the determiner variable has on the outcome variables. For example, the greater the B-value for PU towards ATT, the greater ATT changes when PU changes. Inversely, when a B-value is negative, the outcome variable decreases as the determiner variable increases. All the resulting B-values from this study's regression analysis are presented in the next chapter.

The p-value is the probability of the observed relationship between a determiner and an outcome variable being a result of random error. (Vogt, Vogt, & Gardiner, 2014) Therefore, the lower the p-value for a tested hypothesis, the greater the researcher's confidence that the given result demonstrates a false null hypothesis and the determiner variable demonstrates a real effect on the outcome variable. In order to reject a null hypothesis, the p-values for each hypothesis must be less than the alpha level (α) – the threshold determined by a researcher to reject a null hypothesis. For this study, the alpha level was set to 0.05, which is the conventionally accepted level for social science research (Vogt, Vogt, & Gardiner, 2014). If the p-values for the correlations in this study are less than 0.05, the null hypotheses will be rejected and the effects of the determiner variables on the outcome variables will be deemed to be statistically significant. For example, if the results of this study show that the p-value for the correlation between PU and ATT is less than 0.05, this would indicate that there is a statistically significant relationship between PU and ATT.

**Sampling.** A sampling strategy was developed to recruit the appropriate sample size of nurses to optimize the statistical power of the study. Cohen (1992) identified requirements of samples sizes based on the method of statistical analysis used. Cohen highlights the relationship of three variables used in statistical inference when considering sample size: population effect size (ES), significance criterion (α), and statistical power.

ES describes the degree to which a null hypothesis is indexed by the discrepancy between the null hypothesis and an alternative hypothesis (Cohen, 1992) and indicates the strength of the phenomenon (e.g. the strength of influence of technology characteristic variables to PU and ATT). Cohen proposed guidelines to define effect sizes and described medium effect size as an effect “likely to be visible to the naked eye of the careful observer (1992, p. 156)”. Because there is no indication from previous smartphone studies that a small or large effect is expected, this study assumed a medium effect size in conducting this power analysis. For multiple regression analysis, Cohen indicates the ES index used for power analysis is based from the F test ($f^2$), and he prescribed the appropriate $f^2$-value according to the number of independent variables used in the regression analysis. Based on the seven determiner variables used in this study, Cohen prescribes an $f^2$ value of 0.15.

Alpha level (α), used to measure significance, is the probability of committing a Type 1 error – an error in which the null hypothesis is erroneously rejected when it is actually true. Thus, α provides a measure of the extreme of which the results must be in order to reject the null hypothesis. According to Cohen (1992), the typical α required must be greater than or equal to 0.05 in order for the null hypothesis to be accepted as false. Accordingly, the α for this study was set to 0.05.

Statistical power refers to the probability the statistical test correctly rejects the null hypothesis when it is false. As the power increases, the risk of erroneously failing to reject a null hypothesis that is actually false (Type II error) is decreased. As a standard, Cohen (1992) recommends a power of 0.80 or greater. For this study, a 0.90 power was used for the sample power analysis. This means that when using the sample provided in this study, the analysis will correctly reject null hypotheses that are false nine times out of ten.

The recommended sample size for this study was calculated based on the following values: $f^2$ =0.15, **α** = 0.05, power = 0.9, and independent variables = 7. An a-priori calculation was conducted using the power sampling software application *G*Power* (version 3.1.9.2). The final calculation showed a required sample size of n=129 to achieve a study power of 0.9.

While the minimal sample required to achieve the desired power for this study was n=129, it was important to account for the historically poor response rates of direct care nurses. Van Geest and Johnson (2011) identified that nurse surveys are often characterized by low response rates, typically below 60%. Electronic surveys, when compared to paper surveys, have shown to have an even lower response. Low survey response rates may reflect non-response bias, or the likelihood of systematic differences between those who returned survey and those who did not (Van Gesst & Johnson, 2011). Since evidence indicates that response rates by nurses for electronic survey may range between 2% to 60% (Van Gesst & Johnson, 2011), the total number of respondents invited to participate in the study was increased to 1000. In the event that a poor response rate occurred, this increased the likelihood that this study would achieve its minimum sample requirement (n=129) to protect the statistical power of the study.

A request was submitted to the College and Association of Registered Nurses of Alberta (CARNA) for a contact list of a randomized sample of 1000 RNs. Using the contact list provided by CARNA, potential RN respondents received an email invitation to participate in the study, which included a personalized link to the online survey. At this link, potential respondents were provided an information letter and were asked to verify their consent to participate and confirm their study eligibility.

**Eligibility criteria.** The intent of this study was to investigate the attitudes towards the use of smartphones at work by nurses who provide direct patient care, because previous studies have shown that the slowest uptake of ICTs has been with clinical staff (Eley et al., 2008; Estabrooks et al., 2005; McKnight, 2006). Nurses not providing direct care (e.g. administrative, research, education) have different workflow needs and are not presented the same access challenges to ICTs. Therefore, this study was limited to nurses in clinical roles, which CARNA (2008) defines as "nurses providing direct clinical care, and who are currently a practicing RN in Alberta." Upon receiving the invitation to participate in the survey, respondents were asked to confirm their status as a direct care nurse prior to completing the survey.

**Ethical considerations.** Ethics approval was submitted and received from the Health Research Ethics Board (see Ethics Approval form in Appendix C). Prior to commencing the survey, potential respondents were provided information about the study and how their data would be protected and used. They were also asked to confirm their consent prior to participating. The researcher's contact information was provided to invitees in case respondents had any questions or concerns about the study. Participation in the study was completely voluntary and respondents were permitted to leave the survey at any time by exiting the survey. Surveys terminated prior to completion were not included in the data pool.

The privacy and confidentiality of study invitees was addressed in several ways. In requesting a contact list, the investigator for this study completed a confidentiality agreement with CARNA. In accordance to this agreement, the researcher for this study stored the participant email contacts on a secured hard drive, and this contact list was deleted upon completion of the study. During data collection, the responses of participants were anonymized, and the researcher remained blinded to who was submitting the responses. While the survey was open and responses were being collected, the data was stored on *FluidSurvey's*™ server. When the survey closed, the survey data was transferred and secured onto the hard drive. The data on *FluidSurvey*$^{TM}$ was deleted at the completion of this study.

In this chapter, the research framework, research hypotheses, procedures, and sampling are presented. Using the methodological framework, the data for this study was successfully collected. With this data, further analysis was conducted to test the hypotheses proposed in the research model. The analysis of this data and its implications are discussed in the next chapter, *Data Analysis and Results*.

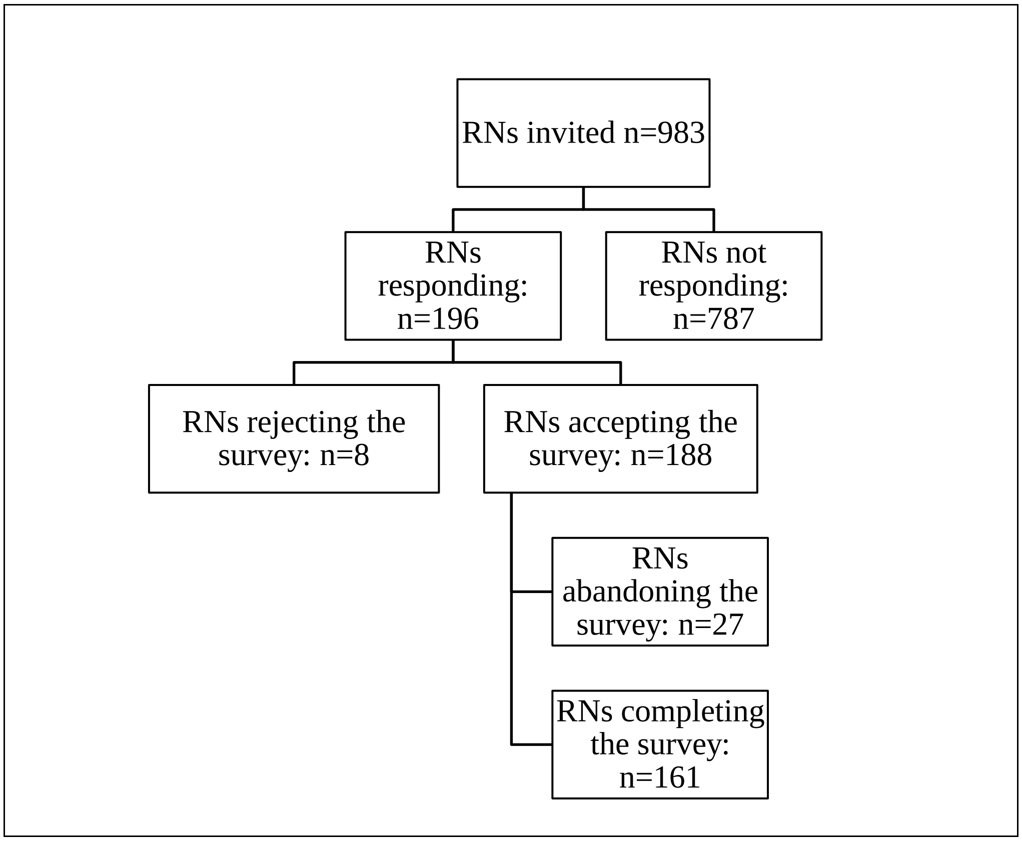
# Data Analysis and Results

The aim of this study was to examine the relationship between nurses' attitudes towards smartphone technology characteristics and their effects on the perceived usefulness and attitudes of using smartphones for work. Using an integrated TAM-TTF research model, RNs were surveyed about their views towards technology characteristics, perceived usefulness, and attitudes about using smartphones for work. Using IBM's *Statistical Package for Social Sciences* (SPSS) version 22, their responses were pooled, and the researcher conducted multiple regression analysis to determine the validity and reliability of the survey instrument, and examine research hypotheses proposed in this study. The findings of these analyses are discussed in this chapter, including the survey response rate, handling of missing data, reliability and validity testing of the survey tool, demographic data results, and hypotheses testing results.

## Survey Response, Acceptance, and Completion Rate

Initially, a sampling frame of 1000 RNs was proposed to increase the probability of achieving the recommended sample size of 129 cases. To deploy the survey, CARNA provided a list of 1000 randomized email contacts of direct care RNs from their membership database. Of note, RN members who indicated their preference not to participate in research were not included in the database randomization. Upon receiving the CARNA email list, several entries were observed to be duplicates. Due to the duplication of contacts on this list, the total number of contacts available to participate was reduced to 983. All 983 of these contacts were emailed an invitation to participate in the online survey.

*Figure 5: Survey Response, Acceptance, and Completion Rates*




Upon entering the survey, respondents were asked to confirm their eligibility and consent. A copy of the email invitation and the consent form are found in Appendices D and E respectively. Of the 983 RNs invited to participate, 196 responses were received – a 19.9% response rate. The responses received were further analyzed to determine the survey termination and abandonment rates. Eight respondents (of 196) terminated their participation prior to commencing the survey, resulting in a 96% acceptance rate. Of the remaining 188 cases, 28 respondents abandoned the survey prior to completing the final question and were excluded in the final analysis. Thus, the final sample size used for analysis was 161 cases, resulting in a survey completion rate of 86% (161 of 188 cases). The response rate analysis is summarized in Figure 5.

In the previous chapter, the a-priori power analysis indicated that a sample size of 129 cases was needed to achieve study power of 0.90. With the final sample size being 161 cases, the desired sample size and power for this study was achieved.

**Handling of Missing Data**

In the final data set, there were several case responses with missing data values. Listwise deletion – the deletion of cases missing data – is the most common method used to address missing data. Experts argue that listwise deletion is a poor approach for handling missing data, because it assumes that the discarded cases are a random subsample (Sterne et al., 2009; Vogt, Vogt, & Gardiner, 2014). Furthermore, listwise deletion leads to other problems: it reduces sample size, which alters the statistical power and precision of the study; it increases the p-values associated with a statistic; and it widens confidence intervals (Schafer, 1999, as cited by Vogt, Vogt, & Gardiner, 2014). If deleted cases are not missing completely at random (MCAR), bias may be inadvertently introduced. Missing data are not often MCAR and it is difficult to determine so without further testing (Sterne et al., 2009; Vogt, Vogt, & Gardiner 2014). Statistical analysts recommend using Little's MCAR test to determine the likelihood that missing data is missing completely at random. If the missing data fails Little's MCAR test, the researcher should then consider the use of statistical methods to address the missing data.

When data are missing at random (MAR), other variables can be used to estimate the missing variables using statistical methods. Experts recommend using multiple imputation (MI) as a viable method for addressing MAR data (Sterne et al., 2009; Vogt et al., 2014). MI uses computer randomization techniques to create several different plausible imputed data sets, estimate missing data, and then appropriately combine results

(Sterne et al., 2009). During MI, the imputed data are sampled from their predictive distribution based on the observed data, then each dataset is analyzed and parametric statistics are computed. At the end of MI, the multiple parametric estimates (e.g. regression coefficients and their associated standard errors) are combined to make final estimates.

In this study, there were thirteen missing responses, which represented 7.8% of the total data collected (see Table 1). Specifically, three survey items (IA1, IA4, and PORT3) were missing two data values each, and seven survey items (COM2, COM3, DS3, AR1, DOC3, PORT1, and PU2) were missing one data value each. Little's MCAR test was conducted on these variables to determine the likelihood they were missing completely at random. In Little's MCAR test, a p-value of less than 0.05 rejects the null hypothesis that no pattern exists. Thus, a rejected null hypothesis means that the missing values demonstrate a pattern that cannot be deemed missing at completely random. When Little's MCAR was conducted for this study, the final p-value was 0.002, rejecting the null hypothesis for MCAR, indicating the missing values were not missing completely at random. Vogt, Vogt, & Gardiner (2014) assert that when the null hypothesis for MCAR is rejected, it is likely that such data is missing at random (as opposed to missing completely at random), and that missing data methods should be used to avoid biasing results by using listwise deletion.

Because the MCAR test showed that the missing data were not missing completely at random, MI was used to impute values for the missing data. In Appendix B, Table 10 summarizes the settings used for the imputation model and Table 11 provides a complete summary of the imputed values for each of the missing cases. In total, five imputations were conducted, the minimum recommended by Vogt, Vogt, & Gardiner (2014). For the final multiple regression analysis, the pooled imputated values were used, along with the remaining survey data values.

*Table 1: List of Missing Data*[a,b]

| | Missing | | | |
|---|---|---|---|---|
| **Variable** | **N** | **Percent** | **Mean** | **Std. Deviation** |
| IA1 | 2 | 1.2% | 4.069 | 0.9079 |
| IA2 | 2 | 1.2% | 4.258 | 0.8945 |
| PORT3 | 2 | 1.2% | 4.126 | 0.8324 |
| PORT1 | 1 | 0.6% | 4.069 | 0.9785 |
| COM2 | 1 | 0.6% | 3.825 | 1.0313 |
| COM3 | 1 | 0.6% | 3.894 | 1.0792 |
| DS3 | 1 | 0.6% | 3.506 | 1.0340 |
| AR1 | 1 | 0.6% | 3.637 | 1.0902 |
| DOC3 | 1 | 0.6% | 3.519 | 1.1214 |

a. Maximum number of variables shown: 25
b. Minimum percentage of missing value for variable to be included: 0.0%

**Reliability and Validity Testing**

Because this study sought to examine operationalizations that have not been previously studied, a new survey instrument had to be developed. The survey items measuring ATT and PU were taken directly from validated TAM healthcare smartphone studies (Park & Chen, 2010; Putzer & Park, 2007; Chen, Park, & Putzer, 2007). However, new survey items were developed to collect data for the technology characteristic variables of this study. These surveys items were based on technology characteristics of mobile ICTs found in previous PDA studies (DiPietro et al., 2008; Doran et al, 2010; Honeybourne, Sutton, & Ward, 2006; Mihailidis, Krones, and Boger, 2006) and from validated TTF studies (Dishaw & Strong, 1995; Goodhue & Thompson, 1990; Hsiao & Chen, 2012; Yen, Wu, Cheng, & Huang, 2010). The new survey instrument was initially tested by five Registered Nurses to ensure clarity of text and content validity. The final version of the instrument used for this study has been included in Appendix E. After the collection of data, further testing was conducted to evaluate the reliability and validity of the survey instrument.

**Reliability.** Trochim and Donnelly (2007) defined reliability as the ratio of variability in true scores to the variability in observed scores. Thus, if a given scale or instrument is unreliable, it fails to consistently measure what it is intended to measure, which severely limits the validity of collected data.

Reliability testing was conducted on all the survey items for each study variable (i.e. ATT, PU, PORT, DOC, IA, DS, AR, and COM) using Cronbach's Alpha. Cronbach's Alpha is a common and widely accepted statistical method to assess the reliability of survey scales (Trochim & Donnelly, 2007; Vogt, Vogt, & Gardiner, 2014). It is a correlation measure of the consistency of answers to items on a scale ranging from 0 (responses that are completely unrelated) to 1.0 (responses that predict one another perfectly). For all of the variables in this study (see results in Table 2), the survey items demonstrated Cronbach's Alpha values ranging from 0.869 (PORT) to 0.965 (PU). The common threshold for scale reliability in survey research is a Cronbach's Alpha value of 0.70 (Vogt, Vogt, & Gardiner 2014); therefore, these results confirmed that all the items used in the survey instrument were statistically reliable.

**Validity.** Validity refers to the extent to which an instrument measures the phenomenon it was designed to measure (Trochim & Donnelly, 2007). While there are numerous forms of validity, construct validity is regarded as the main type to be concerned with in research coding and measurement (Vogt, Vogt, & Gardiner, 2014).

Construct validity is “the degree to which inferences can legitimately be made from the translation of constructs in a study (operationalizations) to the theoretical constructs the translation is based upon (Vogt, Vogt, & Gardiner, 2014, p.56)”. When analyzing construct validity, one must consider its subconstructs – convergent and discriminant validity.

*Table 2: Summary of Cronbach’s Alpha results*

| **Survey Items** | **Cronbach’s Alpha** |
|---|---|
| ATT1, ATT3, ATT3, ATT4 | 0.920* |
| PU1, PU2, PU3, PU4 | 0.965* |
| PORT1, PORT2, PORT3, PORT4 | 0.869* |
| DOC1, DOC2, DOC3 | 0.935* |
| IA1, IA2, IA3, IA4 | 0.903* |
| AR1, AR2, AR3, AR4 | 0.902* |
| DS1, DS2, DS3 | 0.890* |
| COM1, COM2, COM3 | 0.908* |
| *value > 0.70 | |

Convergent validity examines “the degree in which certain operationalizations in a study are similar to other operationalizations that they should be theoretically similar to (Trochim & Donnelly, 2007, p. 61)”. For example, survey items intended to measure ATT should have high correlation values with each other. In contrast, discriminant validity is the degree in which certain operationalizations in a study are dissimilar from other operationalizations that they should dissimilar to. For example, survey items measuring PU should demonstrate lower correlations to survey items measuring ATT. If a survey instrument demonstrates both convergent and discriminant validity, it will also have construct validity.

One method suggested by Trochim and Donnelly (2007) to determine convergent and discriminant validity is by analyzing a correlation matrix of all survey items for a given survey instrument. A correlation matrix compares the correlation values (the statistical relationship between variables) of each survey variable against all other survey variables. As a result, a correlation matrix allows for an assessment of patterns demonstrating convergent and discriminant validity. When analyzing a correlation matrix, there are no concrete thresholds for how high or low correlations need to be to provide evidence for either type of validity; however, convergent correlations should be higher than discriminant ones (Trochim & Donnelly, 2007).

For this study, a correlation matrix was produced using SPSS for all of the survey items representing the ATT, PU, and technology characteristic variables. The complete correlation matrix is available in Appendix A.

The analysis showed that all the technology characteristic variables demonstrated convergent and discriminant validity. For example, items DOC1, DOC2, and DOC3 demonstrated higher correlations ranging 0.777 to 0.916 amongst each other (convergent validity) when compared with their correlations to survey items for ATT, PU, PORT, AR, IA, DS, and COM (divergent validity).

In contrast, some of the ATT and PU variables showed imperfect convergent and discriminant validity patterns. ATT2 showed lower correlations to ATT3 and ATT4 (0.629 and 0.666 respectively). This indicated that ATT2 demonstrated lower convergent validity in this study. When compared to ATT items, ATT3 showed higher correlations to PU3 and PU (0.813 and 0.837 respectively), and ATT4 showed higher correlations to PU1, PU3, and PU4 (0.812, 0.833, and 0.874 respectively). These results indicated that ATT3 and ATT4 demonstrated lower discriminant validity with PU in this study. The correlation matrix for ATT and PU is shown in Table 3.

*Table 3: Correlation Matrix for ATT and PU*

| | ATT1 | ATT2 | ATT3 | ATT4 | PU1 | PU2 | PU3 | PU4 |
|---|---|---|---|---|---|---|---|---|
| ATT1 | 1.000 | .661 | .853 | .814 | .722 | .730 | .778 | .786 |
| ATT2 | .661 | 1.000 | .629 | .666 | .488 | .558 | .565 | .571 |
| ATT3 | .853 | .629 | 1.000 | .829 | .791 | .797 | .813 | .837 |
| ATT4 | .814 | .666 | .829 | 1.000 | .812 | .808 | .833 | .874 |
| PU1 | .722 | .488 | .791 | .812 | 1.000 | .859 | .859 | .876 |
| PU2 | .730 | .558 | .797 | .808 | .859 | 1.000 | .871 | .839 |
| PU3 | .778 | .565 | .813 | .833 | .859 | .871 | 1.000 | .887 |
| PU4 | .786 | .571 | .837 | .874 | .876 | .839 | .887 | 1.000 |

Survey Items for ATT and PU
ATT1: Using a smartphones for work is a good idea.
ATT2: Using a smartphone while working is UNPLEASANT.
ATT3: Using a smartphone is beneficial to my work.
ATT4: I (would) like using a smartphone for work.
PU1: I believe the use of smartphones would improve my job performance.
PU2: I believe the use of smartphones in my job would increase my productivity.
PU3: I believe the use of smartphones would enhance my effectiveness on the job.
PU4: Overall, I (would) find smartphones useful in my job.

Interestingly, the survey items that demonstrated less convergent and discriminant validity were not the items newly created for this study. ATT2, ATT3, and ATT4 were survey items retrieved from a previously validated smartphone acceptance studies (Park & Chen, 2010; Chen, Park, & Putzer, 2007; Putzer & Park, 2007). While these results demonstrated less than optimal convergence and discrimination, data for ATT2, ATT3, and ATT4 were not deleted. According to Chin (1998, as cited by McFarland & Hamilton, 2006), survey items should only be dropped if the violation is a result of a known method variance. Furthermore, McFarland and Hamilton (2006) found that in situations where the violations in convergent and discriminant validity were minor and the internal reliability of the measures was adequate, most researchers disregarded such violations. In assessing the violations in convergent and discriminant validity for this study, it is noted that: (1) no method variance occurred; (2) the imperfect correlations for ATT2, ATT3, and ATT4 were not considerably deviant; and (3) the Cronbach's Alpha results for ATT and PU demonstrated adequate internal reliability (0.920 and 0.965 respectively). In addition to these observations, it is important to consider that the survey items used for ATT and PU have historically demonstrated construct validity (Chen, Park, & Putzer, 2010; Moore & Benbasat, 1991; Park & Chen, 2007; Putzer & Park, 2007; Venkatesh & Davis, 2000). For these reasons, the data collected for ATT2, ATT3, and ATT4 were kept for hypotheses testing. Overall, the survey instrument used in this study demonstrated, while imperfect, acceptable construct validity.

**Demographic Data**

Respondents were asked various questions – including their gender, geography, age category, years of practice as an RN, primary clinical area of work, and self-reported use of a smartphone for work – to capture the demographic data of study participants,.

Of the 161 RN respondents, there were one hundred and fifty-five females (96.3%), and five males (3.1%). One respondent did not report his/her gender (0.006%).

Based on geographical area of place of work, 75.2% (n=121) of respondents reported working in urban/suburban communities as compared to 24.8% (n=40) who reported working in rural/remote communities.

Respondents were asked to select among age ranges based on the generational cohorts proposed by Strauss and Howe (1991). These categories included the Silent Generation (born 1925 - 1942), Baby Boomers (born 1943 – 1960), Generation Xers (1961 – 1981), and Millennials (1982 – 1984). The majority of respondents were Generation Xers (59%), followed by Millennials (24.2%), and Baby Boomers (16.1%).

There were no respondents from the Silent Generation, and one respondent did not report his/her age cohort.

*Table 4: Demographic Data*

| | | **N (%age)** |
|---|---|---|
| **Gender** | Female | 155 (96.3) |
| | Male | 5 (3.1) |
| | No Response | 1 (0.006) |
| **Age Cohorts** | Baby Boomers | 26 (16.1) |
| | Generation X | 95 (59.0) |
| | Millennials | 39 (24.2) |
| | No Response | 1 (0.006) |
| **Years of Practice** | Less than 5 | 21 (13.0) |
| | 5 to 15 years | 61 (37.9) |
| | 16 to 25 years | 39 (24.2) |
| | 26 to 35 years | 27 (16.8) |
| | 36 to 44 years | 12 (7.5) |
| | Greater than 44 years | 1 (0.6) |
| **Geographical Type** | Urban/Suburban | 121 (75.2) |
| | Rural/Remote | 40 (24.8) |
| **Primary Clinical Area** | Acute inpatient care | 36 (22.4) |
| | Community/Public Health | 43 (26.7) |
| | Critical care/Emergency | 26 (16.1) |
| | Facility-living/Long-term care | 10 (6.2) |
| | Mental Health | 11 (6.8) |
| | Maternity/Obstetrics | 8 (5.0) |
| | Outpatient care | 14 (8.7) |
| | Surgical suite/Post-anesthetic recovery | 13 (8.1) |

Based on the number of years of practicing as an RN, the greatest number of respondents reported having practiced for five to ten years (37.9%), followed by those having practiced for sixteen to twenty-five years (24.2%), those having practiced twenty-six to thirty-five years (16.8%), those having practiced for less than five years (13%), those having practiced for thirty-six to forty-four years (7.5%), and lastly those having practiced for greater than forty-four years (0.6%).

Finally, in terms of primary clinical area of work, most respondents reported working in community/public health (26.7%), followed by acute inpatient care (22.4%), critical care/emergency (16.1%), outpatient care (8.7%), surgical suite/post-anesthetic recovery (8.1%), mental health (6.8%), facility-living/long-term care (6.2%), and maternity/obstetrics (5.0%). A summary of all demographic data is provided in Table 4.

## Self-reported Use of Smartphones at Work

To illuminate the self-reported use of smartphones by RNs, respondents were asked how frequently they used smartphones for work purposes. The results showed that the majority of respondents (57.7%) used their smartphones for work at least occasionally, while 23% of respondents reported never using their smartphones for work purposes. A summary of the reported frequency of smartphone use by nurses for work is summarized in Table 5.

*Table 5 Reported frequency of smartphone use for work by nurses.*

| **Response** | **N** | **Percentage** |
|---|---|---|
| Very frequently | 10 | 6.2% |
| Frequently | 34 | 21.1% |
| Occasionally | 49 | 30.4% |
| Rarely | 10 | 6.2% |
| Very rarely | 21 | 13.0% |
| Never | 37 | 23.0% |

## Hypothesis Testing and Results

Null hypothesis testing allows us to statistically test the likelihood that the results achieved in a study are because of an actual relationship between variables, as opposed to error or chance. The data gathered from this survey was analyzed to determine whether to reject a given null hypotheses (no observed significant effect), thus accepting its accompanying alternate hypotheses. Thirteen hypotheses (each with an accompanying null hypothesis) were posited for this study, and each was tested using multiple regression analysis (see Table 8).

**Regression analysis.** Regression analysis provides statistical information to determine the direction of the relationship between determiner and outcome variables (B-value) and whether their relationship is likely a result of chance or error (p-value). For a null hypothesis to be rejected, the p-value for the research hypothesis must be less than the alpha level of this study, which was set at 0.05.

Using SPSS, multiple regression analysis was conducted on the pooled imputed data set. Since the research models for this study required ATT and PU to be each tested as dependent variables, two scenarios were examined: (1) PU as the dependent variable with the technology characteristic variables as determiner variables (Model A), and (2) ATT as the dependent variable, with PU and the technology characteristic variables as determiner variables (Model B). The results of the regression analyses for each of the proposed research hypotheses are listed in Tables 6 and 7 (for Model A and Model B respectively), summarizing the resulting B values, standard error, t-values, p-values, and confidence intervals.

The results showed that four of the research hypotheses (out of thirteen) had p-values less than 0.05; therefore, their null hypotheses were rejected and their alternate hypothesis accepted. The four research hypotheses demonstrating statistically significant results (listed with their accompanying null hypothesis) were:

**H1**: PU has an effect on ATT ($H1_0$: PU will have no effect on ATT);

**H2**: PORT has an effect on ATT ($H2_0$: PO will have no effect on ATT);

**H8:** PORT has an effect on PU ($H8_0$: Port will have no effect on PU);

**H11:** DS has an effect on PU ($H11_0$: DS has will have no effect on PU);

With PU as an outcome variable, PORT, the nurse's attitude towards the portability of smartphones, demonstrated a strong positive effect on PU, the nurse's perceived usefulness of smartphones for work (B = 0.661, p = 1.9825 x $10^{-12}$, 95% CI: 0.477 – 0.845). DS, the nurse's attitude towards decision-support on smartphones, demonstrated a small positive effect on PU (B =0.187, p = 0.035, 95% CI: 0.13 - 0.360). All other hypotheses showed p-values greater than 0.05, so the null hypotheses for H2, H3, H5, and H6 were not rejected. This indicates that a nurse's attitudes towards a smartphone's functionality for documentation (DOC), information access (IA), alerts and reminders (AR), and communications among care providers (COM) demonstrated no statistically significant effects on a nurse's perceived usefulness of using smartphones for work.

With ATT (the attitude of a nurse towards using smartphones at work) as the outcome variable and PU included as one of the determiner variables, PU demonstrated a strong positive effect on ATT (B =0.637; p = 0.0 x $10^{0}$; 95% CI: 0.521 – 0.753). Also within this model, PORT demonstrated a moderate positive effect on ATT (B = 0.324; p = 0.000043; 95% CI: 0.168 – 0.479). All other hypotheses showed p-values greater than 0.05, so the null hypotheses for H10, H11, H12, and H13 were not rejected (The regression analysis for this model is summarized in Table 7). These findings show that the views of nurses towards a smartphone's functionality for documentation, information access, decision-support, alerts and reminders, and communications among care providers demonstrated no significant effects on their attitude towards using smartphones for work.

*Table 6: Regression Analysis (PU as Dependent Variable)*

**Coefficients**[ab]

| | B | Std. Error | T | P-value | 95% Confidence Interval for B Lower bound | Upper bound |
|---|---|---|---|---|---|---|
| (Constant) | -0.975 | 0.281 | -3.466 | 0.001 | -1.527 | -0.424 |
| PORT | 0.661 | 0.094 | 7.041 | $1.9285 \times 10^{-12}$ | 0.477 | 0.845 |
| DOC | -0.050 | 0.069 | -0.719 | 0.472 | -0.184 | 0.085 |
| IA | 0.165 | 0.105 | 1.572 | 0.116 | -0.041 | 0.371 |
| AR | 0.073 | 0.086 | 0.845 | 0.398 | -0.096 | 0.243 |
| DS | 0.187 | 0.089 | 2.106 | 0.035 | 0.013 | 0.360 |
| COM | 0.093 | 0.069 | 1.354 | 0.176 | -0.042 | 0.228 |

a. Dependent Variable: PU
b. R-square: 0.656

*Table 7: Regression Analysis (ATT as Dependent Variable)*

**Coefficients**[ab]

| | B | Std. Error | T | P-value | 95% Confidence Interval for B Lower bound | Upper bound |
|---|---|---|---|---|---|---|
| (Constant) | 0.352 | 0.220 | 1.596 | 0.057 | -0.012 | 0.823 |
| PU | 0.610 | 0.062 | 9.892 | $0.0 \times 10^{0}$ | 0.521 | 0.753 |
| PORT | 0.347 | 0.080 | 4.329 | 0.000043 | 0.168 | 0.479 |
| DOC | -0.013 | 0.051 | -0.253 | 0.800 | -0.112 | 0.086 |
| IA | 0.115 | 0.078 | 1.481 | 0.139 | -0.037 | 0.268 |
| AR | -0.079 | 0.066 | -1.240 | 0.215 | -0.204 | 0.046 |
| DS | -0.114 | 0.066 | -1.723 | 0.085 | -0.243 | 0.016 |
| COM | 0.014 | 0.050 | 0.275 | 0.785 | -0.085 | 0.113 |

a. Dependent Variable: ATT
b. R-square: 0.780

*Table 8: Summary of Research Hypotheses*

| **Alternative Hypothesis** | **P-value** | **Alternate hypothesis accepted** |
|---|---|---|
| H1: PU ➔ATT | $0.0 \times 10^{0}$ | Yes |
| H2: PORT ➔ATT | 0.000043 | Yes |
| H3: DOC ➔ATT | 0.800 | No |
| H4: IA ➔ATT | 0.139 | No |
| H5: DS ➔ATT | 0.215 | No |
| H6: AR ➔ATT | 0.085 | No |
| H7: COM ➔ATT | 0.785 | No |
| H8: PORT ➔PU | $1.9285 \times 10^{-12}$ | Yes |
| H9: DOC ➔PU | 0.472 | No |
| H10: IA ➔PU | 0.116 | No |
| H11: DS ➔PU | 0.035 | Yes |
| H12: AR ➔PU | 0.116 | No |
| H13: COM ➔PU | 0.176 | No |

**Summary**

After statistical analysis of the data, several determinations were made. With respect to the reliability and the validity of the survey instrument, the analysis showed that the instrument is reliable, but demonstrated imperfect validity for ATT and PU. These imperfections were assessed to be inconsequential, but further validation testing of the survey instrument used is warranted. In regards to the hypotheses posited in this study, four of them demonstrated statistical significance: (1) perceived usefulness had an effect on attitude towards using smartphones for work, (2) portability had an effect on attitude towards using smartphones for work, (3) portability had an effect on perceived usefulness, and (4) decision-support had an effect on perceived usefulness. These findings provide further insights to what may impact a nurses' decision to accept a smartphone for work. The implication of these findings is discussed in the next chapter.

# Discussion and Implications

The results of this study have confirmed that PU and PORT have an effect on ATT, and PORT and DS have an effect on PU. These findings provide needed insight about smartphone technology characteristics that influence nurses' perceived usefulness of smartphones and attitudes towards using smartphones for work. The aim of this study was to illuminate such findings to provide new information that could be practically applied by nurse administrators and system designers to optimize smartphone acceptance by nurses. This chapter will discuss the implications of these findings with respect to existing evidence and explore the resulting practical implications.

## Discussion of Findings

Previous nursing smartphone acceptance studies have shown that PU has a significant effect on ATT, but limited evidence has been provided to explain what contributes to PU. This study supports previous findings showing that nurses' perceived usefulness of smartphones has a significant effect on nurses' attitudes towards using smartphone at work. But, this study also provides new evidence that nurses' views on the portability of smartphones and decision-support tools on smartphones have statistically significant effects on their perceived usefulness of smartphones.

**Perceived usefulness and attitude towards smartphones.** TAM posits that the user acceptance of a technology is dependent on the user's perceived usefulness of the given technology. Numerous ICT studies have validated TAM and have confirmed the significant effect of PU to technology acceptance (Venkatesh & Davis, 2000), but there has only been limited research using TAM to examine the acceptance of smartphones by health professionals. In 2007, Park and Chen applied a modified TAM model that integrated the TAM constructs of ATT and PU with factors from Roger's Innovation Diffusion Theory. Their findings showed that the intent for health care staff to use smartphones and their attitudes towards using smartphones were largely influenced by perceived usefulness (Standardized coefficient: 0.806; $p < 0.001$ and a standardized coefficient of 0.904; $p < 0.001$ respectively). In 2010, Chen, Park, and Putzer conducted a similar study and their results also showed that perceived usefulness had a significant effect on a health care user's attitude towards using smartphones (Standardize coefficient of 0.629; $p < 0.000$).

By demonstrating that PU had a significant effect on ATT, the results of this current study support previous findings. However, previous TAM studies have been criticized for providing little practical value (Venkatesh & Davis, 2000), leaving implementers with little information to inform their system design and implementation strategies. This current study addresses this gap by providing new insights about how smartphone technology characteristics affect nurses' PU and ATT towards using smartphones, discussed in the next section.

**The effects of smartphone technology characteristics.** The research model used for this study integrated concepts from TAM and TTF in order to specifically measure the effects of practical technology characteristics on PU and ATT. TTF posits that characteristics of information systems will affect user evaluation of the task-technology fit of a technology and these characteristics are dependent on the technology itself (Goodhue, 1995).

There have been a few studies that have investigated the effects of the technology characteristics of mobile ICTs, and each operationalized technology characteristics differently. Hsiao and Chen (2012) investigated the effects of TTF concepts on the performance of nurses using mobile computing systems. In their study, they operationalized technology characteristics as degree of integration, support functions, and services supports. Their study concluded that these technology characteristics had a significant effect on task-technology fit. However, their operationalization of technology characteristics did not explicitly describe the technical functionality of the mobile nursing computing system that was being used.

Yen et al. (2010) used a TTF-TAM model and found that technology characteristics had a significant effect on the perceived usefulness of wireless handsets ($P<0.05$). In their context, they defined technology characteristics as: (1) ability to receive information and perform transactions, (2) personalization and representation of information for use, (3) ability to disseminate relevant information for a particular locations, and (4) expansion of opportunities to expand client base. However, unlike this current study, their research focused on the use of wireless handhelds for mobile commerce.

For this current study, the technology characteristics variables were derived from previous mobile ICT studies (Doran et al., 2010; DiPietro et al., 2008; Lee, 2006; Mihailidis, Krones, & Boger, 2006). So, unlike Hsiao and Chen (2010), this study operationalized technology characteristics into explicit practical functions (e.g. portability, decision-support, alert and reminders, etc.) in order to elucidate their effects on nurses' perceived usefulness of smartphones. Specifically, this study's results showed that portability and decision-support have statistically significant effects towards nurses' PU of smartphones for work.

***Portability and perceived usefulness.*** By way of digital media, ICTs allow for dematerialization of information – paper copies can now be replaced with digital information that can be easily stored and transferred with reduced transactional costs (Ehrler et al., 2013). While this dematerialization provides an advantage, it creates a strong dependence on computers, which prior to hand-held devices, was associated with decreased mobility for clinicians (Ehrler et al., 2013). With the inception of mobile ICTs (e.g. PDAs and smartphones), the advantages of computer systems can be easily brought to the point-of-care.

This current study directly measured the relationship between the nurses' views on portability and their perceived usefulness of smartphones. At the time this report was written, no other studies were found directly examining this type of effect on the acceptance of smartphones by nurses. There have been previous studies investigating the use of PDAs where nurses were asked to define what would make PDAs useful (Doran et al., 2010; DiPietro et al., 2008; Lee, 2006; Mihailidis, Krones, & Boger, 2006). While the mobility of PDAs was a feature often reported to be useful, none of these studies directly measured its correlation to PDA acceptance. A study conducted by Bullard et al. (2004), examining the use of wireless technology to support the use of electronic clinical practice guidelines (eCPG) by emergency department physicians, found that eCPGs were used more frequently when physicians used wireless technology (i.e. computer-on-wheels) as opposed to hardwired technology. While these results did not explain why technology portability resulted in the increased use of eCPG, the authours speculated that the increased use of eCPGs was likely related to the mobility of the technology, which allowed for the eCPGs to be used closer to point-of-care. This may partially explain why portability had an effect on PU in this current study.

What has not been captured in this current study was how individual nurses conceptualized portability. In their case study of the implementation of a mobile application for clinical practice, Ehrler et al. (2013) acknowledged the difficulty in identifying the best device for the clinical environment, as each possesses their advantages and drawbacks. They recommended that implementers consider hardware criteria, such as hand ergonomics, size, screen resolution, weight, and battery life when selecting a mobile ICT device in order for it to be accepted by end-users. In investigating factors that nurses' believe will improve clinical support systems, Mihailidis, Krones, and Boger (2006) found that handheld devices were not necessarily thought to be portable by some nurses with respect to their nursing workflow, as 75% of nurses indicated their preference for portability as some form of wearable device. These examples demonstrate the subjectivity of portability for nurses. Thus, when evaluating various types of smartphones (or mobile ICTs), implementers should consider portability in the context of the end user's individual needs and workflow. What may be considered a portable device in one context may not be in another, which according to the findings of this current study, will impact the nurses' PU and ATT towards that device.

***Decision support and perceived usefulness.*** Further to studies illuminating the concept of portability, there have been previous studies capturing nurses' views towards electronic decision-support tools. In a systematic review of clinical support systems, Kawamoto et al. (2005) asserted that these systems are effective for improving clinical practices, and summarized that these systems must: (1) provide decision-support automatically as part of clinical workflow, (2) deliver decision-support at the time and location of decision-making, (3) provide actionable recommendations, and (4) use a computer to generate the decision-support. However, While and Dewsbury (2011) claim that different job roles for nurses will demand different uses of ICT, reflecting their role autonomy and practice setting. The results of this current study support this claim, as they show that the extent of which RNs perceive smartphones to be useful for work is closely related to their attitudes toward decision-support on smartphones.

Interestingly, while decision-support demonstrated a statistically significant effect on PU in this study, information access via smartphones did not. This may be explained by the function of decision-support tools to reduce the cognitive load of knowledge workers.  Decision-support is a processed form of information access –information designed or calculated to directly aid clinical decision-making, based on individual patient characteristics and context. Sinclair (1990) asserts the quantity of information available to nurses has now surpassed their capacity to absorb it. As a result, information access alone may have limited utility if nurses are unable to process more information given their cognitive demands. Mobile computing offers an added capacity to effectively filter and/or analyze data, which can take the form of decision-support tools on smartphones. In information-rich environments, the influence of decision-support on PU (when compared to unprocessed information) indicates that nurses may not be only seeking more access to information to perform clinical tasks, but also requiring computing support to help process and deliver information in a form that is usable and timely. However, further exploratory research about nurses' attitudes towards mobile decision-support is needed to explain why decision-support is of greater influence on perceived usefulness of smartphones versus having improved information access alone.

## Practical implications

A major objective of this study was to bring to light new practical insights so that system designers, educators, and administrators can improve the use and acceptance of smartphones by nurses at work. Unlike previous studies, this current study elucidates how smartphone portability and decision-support affected nurses' perceived usefulness and attitudes towards using smartphones for work. Based on these findings, the following practical implications emerge:

1. *Evaluate and design for smartphone portability*. In this study, portability was found to be a key determiner of perceived usefulness and positive attitudes of smartphones by nurses. Portability is partly determined by the physical characteristics of the device, but also by the nature of the nurse's workflow. To improve the acceptance of smartphones by nurses, system implementers, educators, and managers must plan and design for smartphone devices and systems that align with nurses' expectations of portability (which may vary depending on clinical workflow).
2. *Be strategic about the decision-support tools on smartphones*. In this study, attitudes towards decision-support tools were found to be a key determiner of perceived usefulness of smartphones by nurses. Decision-support tools potentially help nurses to process information to make clinical decisions, which may be more valuable than information access alone. Therefore, the value of decision-support tools is likely to depend on a nurse's clinical

decision needs and the acceptability of the decision-support output. To improve the perceived usefulness of smartphones, system implementers must be purposeful about the decision-support tools included on to smartphones. These decision-support tools should align with nurses' clinical needs and help them process information in ways that reduce their cognitive load.

## Conclusion

This study sought to investigate how smartphone technology characteristics affected nurses' attitudes and perceived usefulness of smartphones for work. Using a modified TAM/TTF model, several hypotheses were tested to quantify the effects of smartphone technology characteristics on nurses' perceived usefulness and attitudes towards using smartphones for work. The results of this study showed that nurses' attitudes towards the portability of a smartphone and perceived usefulness of smartphones had a significant effect on their attitudes towards using smartphones for work, and that nurses' attitudes towards the portability and decision-support on smartphones had a significant effect on their perceived usefulness of smartphones and attitudes towards using smartphones for work. Attitudes towards smartphones functionality for information access, documentation, alerts and reminders, and text/voice-call communications did not demonstrate any significant effects on nurses' perceived usefulness or attitudes towards using smartphones for work. These findings confirm that nurses significantly relate the portability and decision-support functionality of a smartphone to their perceived utility of smartphones. As a result, these technology characteristics should be strongly considered when implementing and designing smartphone systems for optimal acceptance by nurses working at point-of-care. While previous studies have either demonstrated the importance of PU and technology characteristics, or highlighted nurse-reported preferences for mobile ICTs, this study bridges these concepts by quantifying the effects technology characteristics have on nurses' perceived usefulness and attitudes towards using smartphones for work. In doing so, this study provides new practical insights to help nurse leaders and health information technologists in designing and implementing smartphone systems for nurses.

**Limitations**

There are several limitations to this study. Firstly, the sampling for this study was limited to a specific geographical location. While respondents were randomized, the end sample only represented RNs working in Alberta, Canada, so caution must be taken in generalizing these findings to a broader professional nurse population. Secondly, because recruitment involved the use of email and electronic survey delivery, there is a risk for response bias. RNs more inclined to use digital technologies may have been more willing to participate in the survey, while RNs having negative views towards smartphones may have been underrepresented in this study. Thirdly, the survey instrument used in this study is novel. While the reliability of the survey instrument tested strongly in this study, there were some inconsistencies in the convergent and discriminant validity of ATT and PU variables. Further testing of the survey instrument used in this study is recommended to establish its longitudinal validity and reliability. Lastly, the design of this study assumed the validity of the TAM and TTF models based on previous model validation research. The main purpose of this study was to test the effects of the determiner variables on the outcome variables, so the statistical methods used were limited in quantitatively validating the model-fit of the TAM/TTF model used. This would require more sophisticated statistical methods of analysis, like structural equation modeling (SEM). Due to the limitations in sample size, the expertise of the researcher, and the resource restraints of this project, using SEM was not possible for this study. If the appropriate sample size is achievable, further research using SEM is recommended.

**Opportunities for Further Research**

At the time of the writing of this report, no other studies were found examining nursing smartphone acceptance with respect to smartphone technology characteristics. While the findings of this study provide new evidence about the effects of technology characteristics on smartphone acceptance, they also uncovered other evidence gaps. This shines a spotlight on further research opportunities.

An opportunity presents to complete a more qualitatively exploration of the views of nurses about using smartphones during work. During the data collection phase of this study, the researcher received emails from respondents articulating their views about the appropriateness of using smartphones at work. Some provided anecdotes about how smartphones were used to optimize their care; others expressed their concerns about the inappropriate personal use of smartphones and the distractions they cause. Exploring the richness of these views would provide further qualitative insights about this topic.

Also, this study did not illuminate why certain technology factors were deemed more important to nurses than others. For example, having information access was not enough for nurses – decision-support had a greater effect in influencing their perceived usefulness of smartphones. Does this suggest that nurses are seeking more than just access to information, and looking for support in managing an influx of information? Portability was a significant determinant of smartphone acceptance by nurses, but what exactly constitutes portability? Is wearable technology perceived as better portability? Do nurses consider tablets portable? A qualitative investigation into these topics will provide further insights to how nurses view technology characteristics such as portability and decision-support, and in turn, elucidate even more practical findings.

Lastly, similar to how smartphones outpaced PDAs, newer and more innovative technologies may someday replace smartphones (e.g. augmented reality technology, wearables, etc.). The findings of this study can inform other investigational designs for emerging technologies to examine how their technology characteristics affect their acceptance by clinical end-users.

**Nurses and Smartphones: Ready-to-Hand**

Nurses are knowledge workers – they generate information and knowledge as a product; they use knowledge to provide best patient care; they capture knowledge to distribute expertise where it can create the largest benefit (Mastrian & McGonigle, 2012). With the appropriate application of information and communication technologies, nurses are provided a tool to exercise their capacity to perform as knowledge workers. The current ubiquitousness of smartphones may provide an opportunity to accelerate nurses' acceptance of clinical ICTs by leveraging their personal familiarity with these devices so they can be utilized in their work lives. In partaking in this project, the researcher of this study saw an opportunity to better understand how and what influences nurses to use ICT tools, like smartphones.

The researcher for this study strongly believes in the value of nurses as care experts and was interested in finding ways to empower them as knowledge workers. However, simply implementing knowledge tools can pose challenges, and historically nurses have been reluctant to use ICTs in their work. The authour's motivation for this study was based on trying to understand these challenges to better develop and implement technologies that center on nurses and their work needs. It is problematic to assume that simply introducing a technology is sufficient to impact care. The introduction of new technology into an already complex care environment requires careful consideration to ensure nurses perceive and receive value from it. It is important to recognize that for a technology to be utilized by a nurse, it cannot be only seen as just an accessory – it must become an extension of the nurse. A technology that extends nursing practice should be designed and implemented to augment and amplify nursing expertise and praxis, while weaving seamlessly into the moment-to-moment interactions of a nurse. In a reflection about providing care in technologically intense environments, Almerud, Alapack, Fridlund, and Ekebergh (2008) wrote:

> "The hammer for the cobbler is ready-to-hand. It is an ordinary extension of the craftsman's arm… So too, the hockey stick or the baseball glove for the sportsman, or for the musician and his violin. By mastering the 'tool', it ceases to be an object and become an extension of the user's arm…The praxis of nursing, which includes handling tools, should embody them similarly: ready-to-hand. When the unity exists, the technological object then blends into the background and become part of the total picture, and in the clinical case, a part of the caring process (p. 59)."

By understanding what contributes to a nurse's perceived usefulness of an ICT, this study demonstrates how ICTs can become an extension of the nurse. Through this project, the researcher has gained greater understanding about how nurses view smartphones – whether they believe smartphones have a place in the caring process and what they believe these technologies need to have characteristically in order for them to do so. The findings from this study provide new practical insights for healthcare decision-makers to consider when designing and implementing smartphone systems to support nurses in their knowledge work – and allow nurses to have smartphones ready-to-hand.

**References**

Almerud, S., Alapack, R. J., Fridlund, B., & Ekebergh, M. (2008). Beleaguered by technology: Care in technologically intense environments: Original article. *Nursing Philosophy*, *9*(1), 55–61. doi:10.1111/j.1466-769X.2007.00332.x

Bassendowski, S., Petrucka, P., Breitkreuz, L., Partyka  M, J., MacDougall, L., Hanson, B., & Ayers, K. (2011). Integration of technology to support nursing practice: a Saskatchewan Initiative. *Online Journal of Nursing Informatics*, *15*(2), 11p. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2011258464&site=ehost-live&scope=site

Benbasat, I., & Barki, H. (2007). Quo vadis, TAM? *Journal of the Association for Information Systems*, *8*, 211–218. doi:10.1586/erd.10.82

Bullard, M. J., Meurer, D. P., Colman, I., Holroyd, B. R., & Rowe, B. H. (2004). Supporting clinical practice at the bedside using wireless technology. *Academic Emergency Medicine*. doi:10.1197/j.aem.2004.08.013

Canadian Nurses Association (2013). *Tested Solutions for Eliminating Canada's Registered Nurse Shortage*. Retrieved from http://www.cna-aiic.ca/~/media/cna/page%20content/pdf%20en/2013/07/26/10/41/rn_highlights_e.pdf

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

Chen, J., Park, Y., & Putzer, G. (2010). An examination of the components that increase acceptance of smartphones among healthcare professionals. *Electronic Journal of Health Informatics*, *5*(2), 1–12. Retrieved from http://www.ejhi.net/ojs/index.php/ejhi/article/view/132

Cohen, J. (1992). Quantitative Methods in Psychology- A Power Primer. *Psychological Bulletin*, *112*, 155–159.

Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results. Management. Retrieved from http://en.scientificcommons.org/7894517

Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task–technology fit constructs. *Information & Management*, *36*(1), 9–21. doi:10.1016/S0378-7206(98)00101-3

Di Pietro, T., Coburn, G., Dharamshi, N., Doran, D., Mylopoulos, J., Kushniruk, A., … McArthur, G. (2008). What nurses want: diffusion of an innovation. *Journal of Nursing Care Quality*, *23*(2), 140–146. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2009881794&site=ehost-live&scope=site

Divall, P., Camosso-Stefinovic, J., & Baker, R. (2013). The use of personal digital assistants in clinical decision making by health care professionals: A systematic review. *Health Informatics Journal*, *19*(1), 16–28. Retrieved from 10.1177/1460458212446761

Doran, D. M., Haynes, R. B., Kushniruk, A., Straus, S., Grimshaw, J., Hall, L. M., … Jedras, D. (2010). Supporting evidence-based practice for nurses through information technologies. *Worldviews on Evidence-Based Nursing*, *7*(1), 4–15. doi:http://dx.doi.org/10.1111/j.1741-6787.2009.00179.x

Doran, D. M., Mylopoulos, J., Kushniruk, A., Nagle, L., Laurie-Shaw, B., Sidani, S., … McArthur, G. (2007). Evidence in the palm of your hand: development of an outcomes-focused knowledge translation intervention. *Worldviews on Evidence-Based Nursing*, *4*(2), 69–77. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2009603290&site=ehost-live&scope=site

Ehrler, F., Wipfli, R., Teodoro, D., Sarrey, E., Walesa, M., & Lovis, C. (2013). Challenges in the Implementation of a Mobile Application in Clinical Practice: Case Study in the Context of an Application that Manages the Daily Interventions of Nurses. *JMIR mHealth and uHealth*, *1*(1), e7. doi:10.2196/mhealth.2344

Eley, R., Fallon, T., Soar, J., Buikstra, E., & Hegney, D. (2008). Nurses' confidence and experience in using information technology. *Australian Journal of Advanced Nursing*, *25*(3), 23–35. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2009881589&site=ehost-live&scope=site

Estabrooks, C. A., O'Leary, K. A., Ricker, K. L., & Humphrey, C. K. (2003). The Internet and access to evidence: how are nurses positioned? *Journal of Advanced Nursing*, *42*(1), 73–81. doi:10.1046/j.1365-2648.2003.02581.x

Featherly, K. & Van Beusekom, M. (2003). Medicine on the move: PDAs and tablet PCs make the rounds with doctors and nurses. Retrieved from: http://www.healthcare-informatics.com/issues/2004/02_04/PDAs_Gatefold. pdf.

Goodhue, D. L. (1995). Understanding User Evaluations of Information Systems. *Management Science*, *41*(12), 1827–1844. doi:10.1287/mnsc.41.12.1827

Goodhue, D. L. (1998). Development and Measurement Validity of a Task-Technology Fit Instrument for User Evaluations of Information System. *Decision Sciences*, *29*(1), 105–138. doi:10.1111/j.1540-5915.1998.tb01346.x

Goodhue, D. L., Thompson, R. L., & Goodhue, B. D. L. (1995). Task-Technology Fit and Individual Performance. *MIS Quarterly*, *19*(2), 213–236.

Hardiker, N. (2012). Developing standardized terminologies to support nursing practice. In McGonigle, D., & Mastrian, K. (Eds.), Nursing informatics and the foundation of knowledge (pp. 111-119). Mississauga, ON: Jones & Bartlett Learning Canada.

Honeybourne, C., Sutton, S., & Ward, L. (2006). Knowledge in the palm of your hands: PDAs in the clinical setting. *Health Information & Libraries Journal*, *23*(1), 51–

59. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2009197620&site=ehost-live&scope=site

Hsiao, J.-L., & Chen, R.-F. (2012). An Investigation on Task-Technology Fit of Mobile Nursing Information Systems for Nursing Performance. *CIN: Computers, Informatics, Nursing*. doi:10.1097/NCN.0b013e31823eb82c

Johansson, P., Petersson, Gör., & Nilsson, G. (2011). Experience of using a personal digital assistant in nursing practice - a single case study. *Journal of Nursing Management*, *19*(7), 855–862. doi:http://dx.doi.org/10.1111/j.1365-2834.2011.01261.x

Kawamoto, K., Houlihan, C. A., Balas, E. A., & Lobach, D. F. (2005). Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *British Medical Journal*, *330*(7494), 765. doi:10.1136/bmj.38398.500764.8F

Kwon, T. H., & Zmud, R. W. (1987). Unifying the fragmented models of information systems implementation. In *Critical Issues in Information Systems Research* (pp. 227–251). Retrieved from http://portal.acm.org/citation.cfm?id=54905.54915

Lee, T.-T. (2006). Adopting a personal digital assistant system: application of Lewin's change theory. *Journal of Advanced Nursing*, *55*(4), 487–96. doi:10.1111/j.1365-2648.2006.03935.x

Lee, C.-C., Cheng, H. K., & Cheng, H.-H. (2007). An empirical study of mobile commerce in insurance industry: Task–technology fit and individual differences. *Decision Support Systems*, *43*, 95–110. doi:10.1016/j.dss.2005.05.008

Lu, Y. C., Xiao, Y., Sears, A., & Jacko, J. A. (2005). A review and a framework of handheld computer adoption in healthcare. *International Journal of Medical Informatics*. doi:10.1016/j.ijmedinf.2005.03.001

Mastrian, K., & McGonigle, D. (2012). Nursing science and the foundation of knowledge. In McGonigle, D., & Mastrian, K. (Eds.), Nursing informatics and the foundation of knowledge (pp. 5-31). Mississauga, ON: Jones & Bartlett Learning Canada.

McFarland, D. J., & Hamilton, D. (2006). Adding contextual specificity to the technology acceptance model. *Computers in Human Behavior*, *22*, 427–447. doi:10.1016/j.chb.2004.09.009

McKnight, M. (2006). The information seeking of on-duty critical care nurses: evidence from participant observation and in-context interviews. *Journal of the Medical Library Association□ : JMLA*, *94*(2), 145–51. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1435853&tool=pmcentrez&rendertype=abstract

Merrigan, G., Huston, C., & Johnston, R. (2012). *Communication research methods* (2nd ed.). New York, NY: Oxford University Press.

Mihailidis, A., Krones, L., & Boger, J. (2006). Assistive computing devices: a pilot study to explore nurses' preferences and needs. *CIN: Computers, Informatics, Nursing*, *24*(6), 328–336. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2009341683&site=ehost-live&scope=site

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

Moore, S., & Jayewardene, D. (2014). The Use of Smartphones in Clinical Practice. *Nursing Management - UK*, *21*(4), 18–22.

Morris, J., & Maynard, V. (2010). Pilot study to test the use of a mobile device in the clinical setting to access evidence-based practice resources. *Worldviews on Evidence-Based Nursing*, *7*(4), 205–213. doi:http://dx.doi.org/10.1111/j.1741-6787.2009.00171.x

Moyer, J. E. (2013). Managing Mobile Devices in Hospitals: A Literature Review of BYOD Policies and Usage. *Journal of Hospital Librarianship*, *13*(3), 197–208. doi:10.1080/15323269.2013.798768

Nagler, A., Schlueter, J., Johnson, C., Griffith, B., Prewitt, J., Adams, M., … Prewitt, J. (2014). Teaching and Learning in Medicine□ : An International Calling for Collaboration□ : Piloting Smartphones to Discover Differences Between Users and Devices Calling for Collaboration, (February 2015), 37–41. doi:10.1080/10401334.2014.910461

Park, Y., & Chen, J. V. (2007). Acceptance and adoption of the innovative use of smartphone. *Industrial Management & Data Systems*, *107*(9), 1349–1365. Retrieved from 10.1108/02635570710834009

Putzer, G. J., & Park, Y. (2010). The effects of innovation factors on smartphone adoption by nurses in community hospitals. *Perspectives in Health Information Management*, *7*, 15p. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2010541580&site=ehost-live&scope=site

Pew Research Centre. (2013). The Smartphone Differences. Retrieved from http://www.pewinternet.org/files/2015/03/PI_Smartphones_0401151.pdf

Rippen, H. E., Pan, E. C., Russell, C., Byrne, C. M., & Swift, E. K. (2013). Organizational framework for health information technology. *International Journal of Medical Informatics*, *82*(4), e1–e13. doi:10.1016/j.ijmedinf.2012.01.012

Sinclair, V. G. (1990). Potential effects of decision support systems on the role of the nurse. *Computers in Nursing*, *8*(2), 60–65.

Sterne, J. A. C., White, I. R., Carlin, J. B., Spratt, M., Royston, P., Kenward, M. G., … Carpenter, J. R. (2009). Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. *British Medical Journal*, *338*(July), b2393. doi:10.1136/bmj.b2393

Straus, W., & Howe, N. (1991). *Generations: The History of America's Future, 1584 to 2069* (1st ed.). New York, NY: William Morrow and Company, INC.

Tapper, L., Quinn, H., Kerry, J., & Brown, K. G. (2012). Introducing handheld computers into home care. *The Canadian Nurse*, *108*(1), 28–32. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/22372098

Thompson, B. W. (2005). The transforming effect of handheld computers on nursing practice. *Nursing Administration Quarterly*, *29*(4), 308–314. Retrieved from http://login.ezproxy.library.ualberta.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=2009059438&site=ehost-live&scope=site

Trochim, W., & Donnely, J. (2007). *The Research Methods Knowledge Base* (3rd ed.). Mason, OH: Cengage Learning.

Venkatesh, V., & Davis, F. (2000). A theoretical extension of the technology acceptance model: Four longitudinal Field Studies. *Management Science*. Retrieved from http://mansci.journal.informs.org/content/46/2/186.short

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). TECHNOLOGY ACCEPTANCE MODEL - Research. *MIS Quarterly*, 425–478. Retrieved from http://www.vvenkatesh.com/it/organizations/Theoretical_Models.asp#Con=structdefs

Van Geest, J., & Johnson, T. P. (2011). Surveying nurses: identifying strategies to improve participation. *Evaluation & the Health Professions*, *34*(4), 487–511. doi:10.1177/0163278711399572

Vogt, P. W., Vogt, E. R., & Gardner, D. C. (2014). *Selecting the Right Analysis for Your Data: Quantiative, Qualitative, and Mixed Methods*. Guilford Press. Retrieved from http://www.myilibrary.com.login.ezproxy.library.ualberta.ca?ID=602645

While, A., & Dewsbury, G. (2011). Nursing and information and communication technology (ICT): A discussion of trends and future directions. *International Journal of Nursing Studies*, *48*(10), 1302–1310. doi:10.1016/j.ijnurstu.2011.02.020

Wu, I.-L., & Wu, K.-W. (2005). A hybrid technology acceptance approach for exploring e-CRM adoption in organizations. *Behaviour & Information Technology*. doi:10.1080/0144929042000320027

Yen, D. C., Wu, C.-S., Cheng, F.-F., & Huang, Y.-W. (2010). Determinants of users' intention to adopt wireless technology: An empirical study by integrating TTF with TAM. *Computers in Human Behavior*, *26*(5), 906–915. doi:10.1016/j.chb.2010.02.005

Yi, M. Y., Jackson, J. D., Park, J. S., & Probst, J. C. (2006). Understanding information technology acceptance by individual professionals: Toward an integrative view. *Information & Management*, *43*(3), 350–363. doi:10.1016/j.im.2005.08.006

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

# Appendix A

## Correlation Matrix

### *Table 9: Correlation Matrix for all ATT, PU, PORT, DOC, IA, AR, DS, and COM Variables*

**Correlation Matrix[a]**

| | | ATT1 | ATT2 | ATT3 | ATT4 | PU1 | PU2 | PU3 | PU4 | PORT1 | PORT2 | PORT3 | DOC1 | DOC2 | DOC3 | IA1 | IA2 | IA3 | IA4 | AR1 | AR2 | AR3 | AR4 | DS1 | DS2 | DS3 | COM1 | COM2 | COM3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Correlation | ATT1 | 1.000 | .661 | .853 | .814 | .722 | .730 | .778 | .786 | .611 | .688 | .602 | .350 | .401 | .352 | .566 | .545 | .481 | .496 | .386 | .407 | .372 | .380 | .391 | .407 | .455 | .364 | .310 | .424 |
| | ATT2 | .661 | 1.000 | .629 | .666 | .488 | .558 | .565 | .571 | .523 | .568 | .466 | .334 | .359 | .332 | .486 | .441 | .334 | .390 | .293 | .321 | .262 | .356 | .315 | .279 | .315 | .386 | .297 | .413 |
| | ATT3 | .853 | .629 | 1.000 | .829 | .791 | .797 | .813 | .837 | .616 | .720 | .618 | .292 | .356 | .313 | .581 | .530 | .495 | .521 | .460 | .463 | .444 | .430 | .426 | .465 | .531 | .361 | .329 | .459 |
| | ATT4 | .814 | .666 | .829 | 1.000 | .812 | .808 | .833 | .874 | .701 | .789 | .669 | .456 | .511 | .441 | .629 | .603 | .563 | .543 | .511 | .493 | .448 | .458 | .467 | .459 | .549 | .425 | .379 | .535 |
| | PU1 | .722 | .488 | .791 | .812 | 1.000 | .859 | .859 | .876 | .658 | .690 | .612 | .402 | .484 | .441 | .557 | .502 | .542 | .529 | .547 | .585 | .539 | .530 | .521 | .481 | .583 | .441 | .442 | .486 |
| | PU2 | .730 | .558 | .797 | .808 | .859 | 1.000 | .871 | .839 | .654 | .709 | .627 | .418 | .440 | .396 | .588 | .550 | .553 | .534 | .486 | .501 | .478 | .516 | .548 | .505 | .618 | .457 | .442 | .528 |
| | PU3 | .778 | .565 | .813 | .833 | .859 | .871 | 1.000 | .887 | .638 | .748 | .620 | .397 | .414 | .372 | .608 | .547 | .530 | .553 | .479 | .514 | .435 | .479 | .528 | .464 | .586 | .402 | .418 | .505 |
| | PU4 | .786 | .571 | .837 | .874 | .876 | .839 | .887 | 1.000 | .651 | .770 | .592 | .368 | .447 | .384 | .614 | .543 | .557 | .567 | .484 | .496 | .449 | .454 | .494 | .465 | .568 | .464 | .437 | .529 |
| | PORT1 | .611 | .523 | .616 | .701 | .658 | .654 | .638 | .651 | 1.000 | .772 | .637 | .488 | .434 | .384 | .546 | .551 | .510 | .457 | .503 | .503 | .525 | .468 | .467 | .467 | .522 | .382 | .350 | .507 |
| | PORT2 | .688 | .568 | .720 | .789 | .690 | .709 | .748 | .770 | .772 | 1.000 | .700 | .461 | .472 | .428 | .599 | .581 | .499 | .569 | .536 | .531 | .516 | .479 | .522 | .493 | .578 | .466 | .403 | .591 |
| | PORT3 | .602 | .466 | .618 | .669 | .612 | .627 | .620 | .592 | .637 | .700 | 1.000 | .544 | .488 | .477 | .630 | .672 | .590 | .597 | .467 | .495 | .493 | .464 | .494 | .545 | .553 | .370 | .316 | .429 |
| | DOC1 | .350 | .334 | .292 | .456 | .402 | .418 | .397 | .368 | .488 | .461 | .544 | 1.000 | .771 | .766 | .524 | .585 | .524 | .469 | .527 | .503 | .559 | .385 | .492 | .473 | .415 | .350 | .420 | .412 |
| | DOC2 | .401 | .359 | .356 | .511 | .484 | .440 | .414 | .447 | .434 | .472 | .488 | .771 | 1.000 | .916 | .559 | .586 | .478 | .488 | .493 | .490 | .537 | .450 | .471 | .387 | .430 | .416 | .402 | .412 |
| | DOC3 | .352 | .332 | .313 | .441 | .441 | .396 | .372 | .384 | .384 | .428 | .477 | .766 | .916 | 1.000 | .552 | .588 | .511 | .532 | .535 | .535 | .539 | .473 | .458 | .396 | .401 | .397 | .430 | .431 |
| | IA1 | .566 | .486 | .581 | .629 | .557 | .588 | .608 | .614 | .546 | .599 | .630 | .524 | .559 | .552 | 1.000 | .808 | .658 | .663 | .448 | .473 | .458 | .460 | .430 | .473 | .535 | .428 | .389 | .476 |
| | IA2 | .545 | .441 | .530 | .603 | .502 | .550 | .547 | .543 | .551 | .581 | .672 | .585 | .586 | .588 | .808 | 1.000 | .676 | .630 | .477 | .496 | .536 | .439 | .491 | .502 | .546 | .408 | .388 | .490 |
| | IA3 | .481 | .334 | .495 | .563 | .542 | .553 | .530 | .557 | .510 | .499 | .590 | .524 | .478 | .511 | .658 | .676 | 1.000 | .722 | .497 | .476 | .556 | .494 | .551 | .533 | .545 | .396 | .452 | .489 |
| | IA4 | .496 | .390 | .521 | .543 | .529 | .534 | .553 | .567 | .457 | .569 | .597 | .469 | .488 | .532 | .663 | .630 | .722 | 1.000 | .461 | .512 | .511 | .386 | .460 | .464 | .492 | .361 | .449 | .446 |
| | AR1 | .386 | .293 | .460 | .511 | .547 | .486 | .479 | .484 | .503 | .536 | .467 | .527 | .493 | .535 | .448 | .477 | .497 | .461 | 1.000 | .874 | .654 | .674 | .540 | .502 | .567 | .433 | .484 | .469 |
| | AR2 | .407 | .321 | .463 | .493 | .585 | .501 | .514 | .496 | .503 | .531 | .495 | .503 | .490 | .535 | .473 | .496 | .476 | .512 | .874 | 1.000 | .672 | .708 | .591 | .535 | .579 | .438 | .454 | .502 |
| | AR3 | .372 | .262 | .444 | .448 | .539 | .478 | .435 | .449 | .525 | .516 | .493 | .559 | .537 | .539 | .458 | .536 | .556 | .511 | .654 | .672 | 1.000 | .588 | .530 | .556 | .536 | .367 | .446 | .442 |
| | AR4 | .380 | .356 | .430 | .458 | .530 | .516 | .479 | .454 | .468 | .479 | .464 | .385 | .450 | .473 | .460 | .439 | .494 | .386 | .674 | .708 | .588 | 1.000 | .527 | .387 | .530 | .539 | .495 | .580 |
| | DS1 | .391 | .315 | .426 | .467 | .521 | .548 | .528 | .494 | .467 | .522 | .494 | .492 | .471 | .458 | .430 | .491 | .551 | .460 | .540 | .591 | .530 | .527 | 1.000 | .691 | .800 | .477 | .492 | .471 |
| | DS2 | .407 | .279 | .465 | .459 | .481 | .505 | .464 | .465 | .467 | .493 | .545 | .473 | .387 | .396 | .473 | .502 | .533 | .464 | .502 | .535 | .556 | .387 | .691 | 1.000 | .677 | .352 | .400 | .385 |
| | DS3 | .455 | .315 | .531 | .549 | .583 | .618 | .586 | .568 | .522 | .578 | .553 | .415 | .430 | .401 | .535 | .546 | .545 | .492 | .567 | .579 | .536 | .530 | .800 | .677 | 1.000 | .446 | .450 | .402 |
| | COM1 | .364 | .386 | .361 | .425 | .441 | .457 | .402 | .464 | .382 | .466 | .370 | .350 | .416 | .397 | .428 | .408 | .396 | .361 | .433 | .438 | .367 | .539 | .477 | .352 | .446 | 1.000 | .842 | .732 |
| | COM2 | .310 | .297 | .329 | .379 | .442 | .442 | .418 | .437 | .350 | .403 | .316 | .420 | .402 | .430 | .389 | .388 | .452 | .449 | .484 | .454 | .446 | .495 | .492 | .400 | .450 | .842 | 1.000 | .691 |
| | COM3 | .424 | .413 | .459 | .535 | .486 | .528 | .505 | .529 | .507 | .591 | .429 | .412 | .412 | .431 | .476 | .490 | .489 | .446 | .469 | .502 | .442 | .580 | .471 | .385 | .402 | .732 | .691 | 1.000 |

a. Imputation Number = Original data

# Appendix B

## Summary of Imputation Settings and Results

***Table 10: Imputation Settings***

| |
|---|
| **Variables included in Imputation:** IA1, IA4, PORT1, PORT3, COM2, COM3, DS3, AR1, DOC3, PU2 |
| Number of Imputations: 5 |
| **Imputation Method:** Automatic (Imputation method is based on a scan of the data) |
| **Constraints:** Minimum value = 1; Maximum value = 5; Rounded to the nearest 1 |

***Table 11: Summary of Imputed Values***

| **Variables** | | **Resulting Imputed Values per Imputation** | | | | |
|---|---|---|---|---|---|---|
| | | **Imputation Number** | | | | |
| | Number of Missing Values | 1 | 2 | 3 | 4 | 5 |
| IA1 | 2 | 4.0, 2.0 | 4.0, 2.0 | 4.0, 3.0 | 4.0, 3.0 | 4.0, 3.0 |
| IA2 | 2 | 4.0, 4.0 | 4.0, 4.0 | 4.0, 4.0 | 3.0, 4.0 | 3.0, 5.0 |
| PORT3 | 2 | 4.0, 4.0 | 4.0, 1.0 | 3.0, 2.0 | 2.0, 2.0 | 3.0, 2.0 |
| COM2 | 1 | 5.0 | 4.0 | 5.0 | 4.0 | 4.0 |
| COM3 | 1 | 3.0 | 5.0 | 5.0 | 4.0 | 4.0 |
| DS3 | 1 | 2.0 | 3.0 | 4.0 | 3.0 | 4.0 |
| AR1 | 1 | 5.0 | 5.0 | 4.0 | 4.0 | 5.0 |
| DOC3 | 1 | 1.0 | 2.0 | 2.0 | 1.0 | 2.0 |
| PORT1 | 1 | 3.0 | 4.0 | 2.0 | 3.0 | 3.0 |
| PU2 | 1 | 1.0 | 1.0 | 1.0 | 1.0 | 2.0 |

# Appendix C

## Ethics Approval Form



### Approval Form

| | |
|---|---|
| Date: | July 14, 2014 |
| Study ID: | Pro00047582 |
| Principal Investigator: | Gordon Gow |
| Study Title: | An Investigation of Technology Factors Influencing Nurses' Perceived Usefulness and Attitudes towards Smartphones |
| Approval Expiry Date: | July 13, 2015 |

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel. Your application, including revisions received June 20 and July 7,12, 2014, has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Alberta Health Services or other local health care institutions for the purposes of the research. Enquiries regarding Alberta Health Services approvals should be directed to (780) 407-6041. Enquiries regarding Covenant Health should be directed to (780) 735-2274.

Sincerely,

Dr. Glen J. Pearson, BSc, BScPhm, PharmD, FCSHP
Associate Chair, Health Research Ethics Board - Health Panel

*Note: This correspondence includes an electronic signature (validation and approval via an online system).*

## Appendix D

### Recruitment Email

Dear [first name, last name],

What do you think about using a Smartphone for your work?

What are your views about the characteristics of Smartphones for the work that you do?

You are being invited to participate in a research study of direct care nurses about their attitudes towards using smartphones at work and smartphone technology factors influencing these attitudes.

This study is being conducted by a researcher at the University of Alberta, Ian Chaves (RN, BScN), as part of his fulfillment of a Master of Arts – Communication and Technology (MACT).

All Registered Nurses (RNs), Registered Psychiatric Nurses (RPNs), and Licensed Practical Nurses (LPNs) providing direct patient care and employed in Alberta, are invited to participate in this study by completing a short online survey.

The findings of the study are intended to provide further learnings to how to design and implement mobile information and communication technologies to support nursing work.

If you think you qualify and would like to participate, and/or require more information about the study, please visit the study's website [insert URL]. At this site, you will be provided further details about the study, participant eligibility, and informed consent. You will not commence the survey until you have electronically confirmed your consent to participate at the study website.

If you have any questions about this study, please do not hesitate to contact Ian directly (ianchaves@ualberta.ca).

Your personal contact information and email address was not provided directly to the researchers – this information has been forwarded on their behalf by [institution name].

Sincerely

[Sending institution] for [Ian Chaves, RN, BScN, MACT(candidate), University of Alberta]

**Appendix E**

**Eligibility Screening, Consent Form, and Survey Instrument**

# Nurses and Smartphones

A Study about Smartphone Factors Influencing Nurses' Perceived Usefulness and Attitudes towards Smartphones

PARTICIPANT INFORMATION LETTER & CONSENT FORM Title of Study: Smartphone Factors influencing Nurses' Perceived Usefulness and Attitudes towards Smartphones  Principal Investigator: Ian Chaves, 780-263-4244  You are being invited to participate in a research study titled “Smartphone Factors influencing Nurses' Perceived Usefulness and Attitudes towards Smartphones”.  This study is being conducted by Ian Chaves from the University Alberta, under the supervision of Dr. Gordon Gow, Director and Associate Professor, Communication & Technology Graduate Program, University of Alberta. What is the reason for doing the study? The purpose of the study is to investigate the influence of smartphone technology factors on nurses’ perceptions about the usefulness of smartphones, and their attitudes towards using smartphones. We hope the findings will help healthcare administrators, educators, and informatics professionals to optimize the policy, design, and implementation of mobile information technologies for clinical use by nurses. Why am I being asked to take part in this research study? For this study, we are seeking responses from Registered Nurses (RNs), who provide direct patient care, about their views towards the use of smartphones for their work. This participation is completely voluntary. Your contact information was provided to us by the *College and Association of Registered Nurses of Alberta* (CARNA) as you have indicated your willingness to participate in research per your CARNA profile.  You have the option of changing this consent by logging onto MyCARNA from the CARNA website.  If concerns persist, the individual should be directed to contact the Privacy Officer of CARNA at privacyofficer@nurses.ab.ca. Upon completion of the data collection for this study, the researchers' will delete the information used to contact potential respondents. What will I be asked to do? You will be asked to complete a one-time survey by completing an online questionnaire. The online questionnaire is composed of 34 questions, which will take approximately 15 minutes to complete. With these questions, you will be asked about general demographic information (e.g. age, years of work) and to rate your level of agreement to various statements about the use of smartphones and characteristics of smartphone technology. To participate in the study, you must meet ALL of the following criteria:  You are currently registered with The College & Association of Registered Nurses of Alberta (CARNA);  You are currently employed as a practicing RN in Alberta;  You are currently in a role where your PRIMARY function is to provide nursing care to patients, families, and/or populations (e.g. nurse managers or nurse educators would be excluded). You will be asked to confirm your eligibility prior to disclosing any responses to the survey. What are the risks and discomforts? We believe there are no known risks associated with this research study. How will you maintain the confidentiality of my information? All information disclosed in this study will be kept confidential – your individual responses and information will not be shared to anyone except between the identified researchers conducting this study. With any online related activity the risk of a breach of confidentiality is always possible. To the best of our ability your answers in this study will remain confidential and we will take several steps to minimize risks. First, we will anonymize your participation -- we will not know your identity as you complete the survey. Second, your responses will be de-identified, meaning that we will not know which responses are yours. Lastly, your survey responses will be encrypted and stored on a Canadian server through a third-party service, Fluid Survey. Upon completion of the data collection, response data will be transferred to a secured hard drive. Upon completion of data analysis, data held on the Fluid Survey server. All data collected and stored on the researcher's secured hard drive will be erased five years after the completion of this study. What are the benefits to me? The findings of the study are intended to contribute to the current body of knowledge about using mobile information and communication technologies to support nursing practice. Individually, you are not expected to get any specific benefits from participating in this research study. Do I have to take part in the study? Your participation in this study is completely voluntary. You are not obliged to answer all or any specific question. You may withdraw at any time by exiting the survey, so long that it's prior to submitting your final response. If after submitting the survey you would like to withdraw yourself from the study, you must contact the researchers by email within five business days to have your responses removed. In order to remove your responses, the research may ask you for information about when you completed the survey. What will it cost me to participate? You will incur no financial costs in participating in this study. Will I be paid to be in the research? You will not be paid to participate in this study. Will my responses be used in any other way? The aggregate results of this study may be published in academic journals or presented in professional presentations (e.g. conferences). No individual identities or information will be revealed for these uses, and further uses will need to be approved by a research ethics board. The final study report will be made available publicly at the University of Alberta Libraries' Education and Research Archives (https://era.library.ualberta.ca/public/home). The raw data collected through this study will not be provided or used for any additional purposes by employers or regulatory bodies. What if I have questions? If you have any questions, concerns, or complaints about the research now or later, please contact: Researcher: Ian Chaves, (780.263.4244 or ianchaves@ualberta.ca) Supervisor: Dr. Gordon Gow (gordon.gow@ualberta.ca) If you have any questions regarding your rights as a research participant, you may contact the Health Research Ethics Board at 780-492-2615. This office has no affiliation with the study investigators. If you would like to participate, please select NEXT to continue to the participant consent form. Select EXIT SURVEY if you do not what to participate in this study.

## Confirmation of Eligibility

There are three criterion for legibility: (1) You are currently registered with the College & Association of Registered Nurses of Alberta (CARNA); (2) You are currently employed as a practicing RN in Alberta; (3) You are currently in a role where your PRIMARY function is to provide nursing care to patients, families, or populations (e.g. nurse managers would be excluded)

**Do you fulfill ALL of the requirements to participate in this survey listed above?**

- ○ Yes
- ○ No

## Participant Consent

To participate in the survey, respondents must complete this participant consent form. The following questions are based on the information from the previous page. Participation in this survey is completely voluntary, and you may choose to exit at anytime, prior to completing the survey.

**Do you understand that you have been asked to participate in a research study?**

- ○ Yes
- ○ No

**Have you read the participant consent information on the previous page?**

- ○ Yes
- ○ No

**Do you understand the benefits and risks involved in taking part in this research study?**

- ○ Yes
- ○ No

**Have you been provided the contact information of the researchers to ask questions about this study?**

- ○ Yes
- ○ No

**Have you reviewed the information about the issue of confidentiality on the previous page?**

- ○ Yes
- ○ No

**By selecting “I agree” below, I am indicating that I am at least 18 years old, have read and understood this consent form and agree to participate in this research study.**

- ○ I agree
- ○ I decline

**Please enter the date of your confirmation of consent (YYYY-MM-DD).**

____/__/__ (YYYY/MM/DD)

**Press NEXT to submit your responses. You will be taken automatically to the appropriate page based on your responses.**

## Part A: Demographic Data

The following questions collect demographic information about the survey participants. Please select the responses that best describe you.

**1. What is your gender?**

- ○ Female
- ○ Male

**2. What is your age?**

- ○ 18 to 34 years old

- ○ 35 to 54 years old
- ○ 55 to 72 years old
- ○ 73 years old or older

**3. How long have you worked as a Registered Nurse?**

- ○ less than 5 years
- ○ 5 to 15 years
- ○ 16 to 25 years
- ○ 21 to 25 years
- ○ 26 to 35 years
- ○ 36 to 44 years
- ○ Greater than 44 years

**4. Which of the following BEST describes the type of location of your primary place of employment?**

- ○ Urban/Suburban
- ○ Rural/Remote

**5. Which of the following BEST describes your primary area of clinical practice? Please select one.**

- ○ acute inpatient care
- ○ critical care/emergency
- ○ community/public health
- ○ outpatient care
- ○ surgical suite/post-anesthetic recovery
- ○ facility-living/long-term care
- ○ maternity/obstetrics
- ○ mental health

### 6. How often do you use a smartphone for nursing-related work?

- ○ never
- ○ very rarely
- ○ rarely
- ○ occasionally
- ○ frequently
- ○ very frequently

## Part B: Attitudes towards Smartphones

Part B is comprised of survey items relating to your attitude towards using a smartphone for nursing work. For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

### 7. Using a Smartphone for work is a good idea.

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

### 8. Using a smartphone while working is UNPLEASANT.

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

### 9. Using a smartphone is beneficial to my work.

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree

- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

### 10. I (would) like using a smartphone for work.

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

## Part C: Perceived Usefulness of Smartphones

Part C is comprised of survey items relating to your perceived usefulness towards using a smartphone for nursing work. For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

### 11. I believe the use of smartphones would improve my job performance.

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

### 12. I believe the use of smartphones in my job would increase my productivity.

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

**13. I believe the use of smartphones would enhance my effectiveness on the job.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

**14. Overall, I (would) find smartphones useful in my job.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

## Section D: Portability

Smartphones provide an increased level of portability compared to desktop computers and laptops. Based on your beliefs and experiences, to what extent do you agree with the following statements about the portability of smartphones for your work? For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

**15. Considering the type of work I do, a smartphone would be easy for me to carry around to do my job.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

**16. I believe a smartphone would be useful for the work I do because it is a handheld device.**

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

**17. Generally, I believe the portability of a smartphone makes its more useful than a technology that is not mobile.**

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

## Section E: Data Entry/Documentation

Smartphones can be used to record data, and could be used to record/track the care you provide. For the next statements, assume that you are using smartphones connected to a secure network at work. Based on your beliefs and experiences, to what extent do you agree with the following statements about how smartphones would allow you to record data and/or document care? For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

**18. A smartphone would help me keep track of information I collect throughout the workday more easily.**

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree

○ 5 - Strongly Agree

**19. It would be easy for me to use a smartphone to document the care I provide.**

○ 1 - Strongly Disagree
○ 2 - Disagree
○ 3 - Neither Disagree Nor Agree
○ 4 - Agree
○ 5 - Strongly Agree

**20. I believe smartphones would make it easier to record clinical data and document my care.**

○ 1 - Strongly Disagree
○ 2 - Disagree
○ 3 - Neither Disagree Nor Agree
○ 4 - Agree
○ 5 - Strongly Agree

## Section F: Information Access

Smartphones can be used to access digital information resources and databases, through apps or websites. For the next statements, assume that you are using smartphones on a secure network at work and can access clinical information and databases. Based on your beliefs and experiences, to what extent do you agree with the following statements about how smartphones provide you access to information? For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

**21. Using a smartphone would allow me to access information at the bedside more easily.**

○ 1 - Strongly Disagree
○ 2 - Disagree
○ 3 - Neither Disagree Nor Agree

- 4 - Agree
- 5 - Strongly Agree

**22. Using a smartphone at work would help me retrieve clinical information more easily to perform patient care.**

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

**23. Using a smartphone would allow me to retrieve clinical policies and procedures more easily.**

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

**24. Using a smartphone would be useful to access information for safe medication administration.**

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

## Section G: Alerts and Reminders

Smartphones can be configured to provide clinical alerts and reminders, like when a task is due or if a patient's test result is critical. For the next statements, assume that you are using smartphones capable of providing clinical alerts and reminders. Based on your beliefs and experiences, to what extent do you agree with the following statements about how smartphones provide with alerts and reminders while you work? For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

### 25. Reminders from a smartphone would help me be better organized in my care.

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

### 26. Receiving reminders from a smartphone would help me do my job more effectively.

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

### 27. Receiving clinical alerts about clinical information (e.g. you patient's critical lab values) from a smartphone would help me provide more effective care.

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

**28. Considering my work environment, I would likely be ATTENTIVE to alerts from a smartphone.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

## Section H: Decision Support

Smartphones can be equipped with tools for decision support, like algorithms (e.g. ACLS), scales (e.g. the Braden Scale), and calculators (e.g. Body-surface area).For the following statements, assume you are using a smartphone that provides you decision tools for your clinical area. Based on your beliefs and experiences, to what extent do you agree with the following statements about the usefulness of smartphones to provide you with clinical decision support? For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

**29. Decision support information from a smartphone would improve the speed of my decisions at the bedside.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

**30. Using a smartphone for computing (e.g. calculators and assessment scales) would improve how I process clinical information.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree

- ○ 5 - Strongly Agree

**31. Using a smartphone for decision support would help me make more accurate clinical decisions.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

## Section I: Communications with Team Members

Smartphones can be used to communicate directly with other health care team members using text or voice call functions. For the next statements, assume that you are permitted to use text and voice calls to communicate with your health care team on a secure network. Based on your beliefs and experiences, to what extent do you agree with the following statements about the usefulness of smartphones to communicate with other health care team members? For the each statement, please rate your level of agreement, where 1 is "strongly disagree", 2 is "disagree", 3 is "neither disagree or agree", 4 is "agree", and 5 is "strongly agree".

**32. Using a smartphone would help me share patient care information more effectively with the other health care team members.**

- ○ 1 - Strongly Disagree
- ○ 2 - Disagree
- ○ 3 - Neither Disagree Nor Agree
- ○ 4 - Agree
- ○ 5 - Strongly Agree

**33. Using a smartphone would improve the speed of communication among my healthcare team.**

- ○ 1 - Strongly Disagree

- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree

**FINAL SURVEY QUESTION -- 34. Considering my work environment and workload, I would be able to use a smartphone to communicate with other healthcare team members.**

- 1 - Strongly Disagree
- 2 - Disagree
- 3 - Neither Disagree Nor Agree
- 4 - Agree
- 5 - Strongly Agree