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THE DIFFUSION OF TELEHEALTH:
SYSTEM-LEVEL CONDITIONS FOR SUCCESSFUL ADOPTION

by

Danika Tynes

A Dissertation
Submitted to the Graduate School,
the College of Arts and Sciences
and the School of Social Science and Global Studies
at The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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ABSTRACT

Telehealth is a promising advancement in health care, though there are certain conditions under which telehealth has a greater chance of success. This research sought to further the understanding of what conditions compel the success of telehealth adoption at the systems level applying Diffusion of Innovations (DoI) theory. System-level indicators were selected to represent four components of DoI theory (relative advantage, compatibility, complexity, and observability) and regressed on 5 types of Telehealth (Teleradiology, Teledermatology, Telepathology, Telepsychology, and Remote Monitoring) using multiple logistic regression.

Analyses included data from 84 states leveraging data from the World Health Organization, World Bank, ICT Index, and HDI Index. The analyses supported relative advantage and compatibility as the strongest influencers of telehealth adoption. These findings help to quantitatively clarify the factors influencing the adoption of innovation and advance the ability to make recommendations on the viability of state telehealth adoption. In addition, results indicate when DoI theory is most applicable to the understanding of telehealth diffusion. Ultimately, this research may contribute to more focused allocation of scarce health care resources through consideration of existing state conditions available to foster innovation.

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LIST OF ABBREVIATIONS

ANT	Actor Network Theory
DoI	Diffusion of Innovation Theory
EHR	Electronic Health Records
GoE	Global Observatory on eHealth
HDI	Human Development Index
ICT	Information Communication Technology
NPT	Normalization Process Theory
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
UN	United Nations
UNDP	United Nations Development Programme
UTAUT	United Theory of Acceptance and Use of Technology
WHO	World Health Organization

CHAPTER I - INTRODUCTION

Globally, the healthcare burden is increasing, with healthcare workers disproportionately scarce (Ozuah & Reznik, 2004), populations aging and increasing rapidly (Dzenowagis, 2009), access disparities growing (Burwell & Saucier, 2013), and communicable and non-communicable diseases rising (NIC, 2000). Innovations in technology are making it possible to help address these challenges (WHO, 2009). One innovation, telehealth, is the provision of care at a distance (Stroetmann et al., 2010), which extends the potential to transform population health through increasing access to quality health care (Statchura & Khashanshina, 2004; WHO, 2009). This dissertation research specifically seeks to further the understanding of what conditions compel the success of telehealth adoption at the systems level. This is an important question and is inspired by the instances of telehealth that have been so beneficial to so many (Elder & Clarke, 2009; Grady, 2014; Wamala and Augustine, 2013; Wootton et al., 2009; WHO, 2009); yet it remains that broad telehealth adoption has not yet fully diffused into state health care systems (Rogers, 2003; Wootton et al., 2009).

Information today is far less expensive to shift around than people, and the ability to transcend geographical distances and provide health care despite location contributes to more timely diagnosis and clinical treatment than standard health care delivery alone (Zundel, 1996). In a study of 184 states, it was found that, based on trends in global spending on health, costs are expected to increase from $7.83 trillion in 2013 to $18.28 trillion in 2040 (Dieleman et al., 2016). With mounting health care costs, innovations in health care are essential to the well-being of populations, of communities, and of families, as “no nation can afford to replicate comprehensive healthcare resources in every large and small community” (Statchura & Khashanshina, 2004, p. 6).

Telehealth positively affects many community challenges, such as loss of productivity time, arriving at health care appointments (Grady, 2014), geographic access gaps closure, increased access to specialty care, better continuity of care, and higher quality, more robust access to information (Gagnon et al., 2006). These benefits help to optimize a given health care network and the limited health resources available to populations. Telehealth can facilitate the attainment of more positive health outcomes (Grady, 2014), and an enhanced understanding of how it can be most successful and effective will help to further advance those outcomes.

Telehealth is a promising advancement that has demonstrated its viability as a health care system adjunct, yet as will be reviewed herein, broad diffusion (Rogers, 2003) of an innovation can meet with many barriers. With all its promise for transforming health care, it remains that there are certain conditions under which telehealth has a greater chance of success (Wootton et al., 2009). Better understanding the factors that influence a successful system-wide application of telehealth is important to advancing the academic and practical knowledge-base and contributing to a reliable body of literature to help guide the proper application of telehealth under the right conditions.

Research Question

This research probes into why telehealth is successfully adopted in some states and what factors contribute to that success (Statchura & Khashanshina, 2004; Zanaboni & Wootton, 2012). It addresses the following central research question: What are the main factors influencing successful telehealth adoption at the health care system level of analysis? Understanding the factors that drive the development of a successful path to adoption, and therefore successful outcomes (i.e., access to care, patient satisfaction, quality of care) can help to better route resources where they can be most effective (Gagnon et al., 2006; Mistry, 2012). This is an important addition to the literature because, while systems-level adoption has been measured (WHO, 2016), those factors that contribute to success have not been comprehensively applied to understanding why some states adopt successfully and others do not (Demiris & Tao, 2005; Khanal et al., 2015; Wootton, 2009).

The research question is addressed by applying Diffusion of Innovation Theory (DoI) and its characteristics of innovation (Rogers, 2003). DoI theory focuses on the decision-making process leading to the adoption or rejection of an innovation (Rogers, 1962). Diffusion is regarded by Rogers as a societal-level function of social change, which is why this theory is appropriate to guide the research inquiry. This theory has been applied to the study of telehealth in local and state-level contexts (Peeters et al., 2012) and, as discussed in Chapter II (literature review), is the most applicable theory to support answering the research question posed above.

Hypotheses

Rogers' (2003) central characteristics of the innovation component of diffusion include relative advantage, compatibility, complexity, and observability. These four characteristics, the independent variables, will be tested using ordinal logistic regression analysis for their influence on successful telehealth adoption (the dependent variable), as measured by the World Health Organization (WHO, 2015). The hypotheses are as follows:

H_1: Relative advantage affects successful telehealth adoption.

H_2: Compatibility affects successful telehealth adoption.

H_3: Complexity affects successful telehealth adoption.

H_4: Observability affects successful telehealth adoption.

Relative advantage, as it pertains to telehealth, is the difference between maintaining a traditional health care system delivery model and adopting a new method of delivery built on a new technological infrastructure and new clinical workflows (Hillman & Schwartz, 1985). Compatibility is observable by reviewing the values and attitudes of potential adopters (Zanaboni & Wootton, 2012). Complexity in telehealth adoption is often cited as barriers in cost and infrastructure readiness (Alkraiji, Jackson, & Murray, 2012; Schwamm, 2004). Observability owes to observable health care outcomes that can be directly linked to telehealth adoption within health care systems (WHO, 2009). In the context of the research question, it is expected that higher perceptions of relative advantage, greater compatibility, lower complexity and higher observability would lend to successful telehealth adoption.

Methodological Approach

This dissertation employs quantitative analysis (Wooldridge, 2009) to better understand the factors involved in successful telehealth adoption and diffusion. This method is applied to determine the conditions under which telehealth adoption is viable. The ordinal dependent variables, systems-level adoption across five domains of telehealth, are measured using published data sponsored by the World Health Organization (*n*=84; WHO, 2016). For those same states, three data sets are included for measurement of the continuous independent variables, representing the DoI innovation characteristics: World Bank data (2015); Human Development Index (HDI) and perception of health data published by the United Nations Development Programme (2016); and data from the Information Communication Technology Index (ITU, 2015).

To measure Rogers' component of innovation, systems-level indicators were selected from the telehealth literature that aligned with each of the four characteristics (relative advantage, compatibility, complexity, and observability). Here, institutional-level variables are drawn from the telehealth diffusion literature to better identify what conditions foster increased likelihood of telehealth uptake and long-term success (Dearing, 2009). The independent variables by DoI component are as follows:

1. Relative Advantage: Child mortality rate under five (World Bank, 2015); Life expectancy (World Bank, 2015); Health care expenditures per capita (World Bank, 2015); Communicable and non-communicable disease (World Bank, 2015); and, population over age 65 (World Bank, 2015).
2. Compatibility: Rural population (World Bank, 2015); Out-of-pocket health care expenses (World Bank, 2015); Information Communication Technology (ICT) Index (ITU, 2015).
3. Complexity: Community health care workers (World Bank, 2015); and, availability of physicians (World Bank, 2015).
4. Observability: Individual perceptions of health quality (UNDP, 2016), Human Development Index (UNDP, 2016).

Variables and the measurement of the construct have been selected from related research. These variables, how they are measured, and their sources are described and explained in Chapter III, methodology. Quantitative analysis is used to address the research question and test hypotheses by regressing the continuous independent variables on the ordinal dependent variables using logistic regression (Wooldridge, 2009). This analysis will assess predictability of telehealth adoption at the institutional-level and further identify the best fitting model (Wooldridge, 2009).

Contributions to the Literature

This research is important for advancing the telehealth literature through quantitative analysis and theory-validation, and by advancing the understanding of the key factors driving telehealth adoption. Within this burgeoning body of telehealth literature (Moser et al., 2004; Yang et al., 2015), most early research focused on individual telehealth projects, the types of technology used, the costs of developing such programs, and the nuances of successes and failures (Moore, 1999). As research develops and the innovation of telehealth becomes further substantiated, more policy concerns are being considered (Stroetmann et al., 2010), making the ability for broader generalizations increasingly relevant. Scholars and institutions have combined volumes of research to synthesize differing perspectives on telehealth to start bringing together the disparate research sources into a more cohesive body (Piette et al., 2012). Accordingly, there is an opportunity in the existing body of literature to begin to generalize what contributes to adoption (Piette et al., 2012), and what has not yet been observed is a large-scale view of state adoption and the potential reasons for success.

Global health is a concern to individuals worldwide, as sustainable well-being drives abundant resource allocation. It is valuable to understand how best to apply resources to yield more positive outcomes for more people to best address the global burden of disease (Ravishankar et al., 2009). Within International Development, scholars and practitioners are concerned with divergent paths of state development (Todaro & Smith, 2009), as well as human development (Sen, 1999), particularly the health of populations, as a major social factor influencing the well-being of nations (Kleinman, 2010). The remote village that is able to receive pre-natal care as a result of telehealth has immense downstream effects on maternal well-being, child well-being, educational and productivity attainment. As global health is a top concern worldwide (Pew, 2014), the influence of institutions has important direct relationships with human well-being because institutions set agendas and derive how efforts are spent, especially when concerning those who are disadvantaged (Bjornskov, Drener, & Fischer, 2010). As institutions play a major role in the direction of health system strengthening, this research will deep dive into institutional variants that contribute to the adoption of telehealth.

Summary

Telehealth can help to reduce the global burden of disease, as its application has demonstrated improvements in access to care and population health (Wootton et al., 2009). In bringing health care to the patient, telehealth has been a powerful and innovative tool for the delivery of services, whether at home, in a health care facility, or wherever it closes the access gap, such as in ambulances (WHO, 2009). Telehealth facilitates rapid dissemination of new discoveries, diffusion and adoption of common standards toward increasing the quality and delivery of care, support for and increased use of pharmaceuticals, diagnostic equipment and other health care-related tools and, new clinical and specialty services (Statchura & Khashanshina, 2004). Yet, telehealth is an expensive adjunct to existing healthcare systems. Many have tried and failed despite its benefits.

Understanding the factors in predicting a successful path to adoption, and therefore successful outcomes (i.e., access to care, patient satisfaction, quality of care) can help to limit failed attempts and route resources to where they can be most effective. To this end, this research fills a gap in the existing literature by uniquely extending a systems-level view of state telehealth adoption including a probe into the associated factors of success. In this analysis, the DoI theory characteristics, or the constructs being measured by the proposed independent variables, provide a quantitative path to identifying the conditions under which telehealth adoption has increased opportunity for success.

It is the intent in these next chapters to more fully explore under what conditions state health care systems are best poised to leverage telehealth as part of their system delivery infrastructures. Chapter II, literature review, elucidates the history of telehealth literature, the significance of the inquiry, theoretical frameworks, and how the literature culminates to support the research question and hypotheses. Chapter III, methodology, details why the quantitative method was selected to help answer the research question and assess the extent of the validity of the hypotheses, how the variables were selected for the models, and how the data was aggregated for analysis. Chapter IV represents the presentation of results, wherein the descriptive data for the DoI characteristics and the regression results for each of the models pertaining to each of the hypotheses are presented. Chapter V extends analysis and interpretation of the results, and Chapter VI, conclusions, summarizes findings in light of the central research question, and also explores how these findings integrate with existing literature. Implications of these results are also discussed along with any study limitations and recommendations for future research.

CHAPTER II – LITERATURE REVIEW

Introduction

Global healthcare systems are shouldering increasing health burdens, requiring governments to adapt to demands for human, financial, and institutional resources (Pew, 2014; Ravishankar et al., 2009), which makes innovation in health care a critical issue for analysis (WHO, 2016). The World Health Organization (WHO) has allocated attention to the leveraging of health care information technology to support its health targets for development goals (Piette et al., 2012). The focus on integrated, sustainable care as a global concern is becoming more visible due to the aging of populations and increased number of births globally (Burwell and Saucier, 2013); this increases the population size relying on health care delivery. In response, there is a push toward innovation to not only service a growing population, but also address diverse health care challenges such as access to care (Piette et al., 2012).

Telehealth, or providing health care services at a distance leveraging technology (WHO, 2009), is one innovation that can positively contribute to world-wide gaps in access to health care (Burch, 2017), yet it is widely observed that its implementation has met with mixed outcomes (van Dyk, 2014; Wootton et al., 2001). Despite the research available on the benefits of telehealth (Gagnon et al., 2006; WHO, 2016), it is still unclear why some states have successfully integrated telehealth into their health care systems while others do not share the same success (Wootton et al., 2009). This is the problem that this study aims to address.

The purpose of this study, then, is to examine the institutional factors that influence telehealth adoption. As the burdens on health systems grow, it is worthwhile to better understand those innovations, like telehealth, that may help alleviate the state shouldered burdens of health outcomes, costs, and patient experiences (Pal et al., 2004). Moreover, understanding the factors that drive the development of a successful path to adoption, and therefore successful outcomes (i.e., access to care, patient satisfaction, quality of care) can help to better route resources where they can be employed most effectively (Gagnon et al., 2006; Mistry, 2012).

The following sections will unfold to elucidate how the central research question came about and how the central arguments will contribute to the existing literature. This chapter is thus organized as follows: First, the health care burden is explained, under which the effects of telehealth becomes important. Second, a historical review of telehealth explains how telehealth came about and how it is employed, followed by a summary of the systematic review of reviews to note where the literature stands in its maturity. Third, the significance of the research will be discussed. The fourth section presents and discusses the theoretical frameworks and models that apply to telehealth, focusing on the Diffusion of Innovation theory as the primary theoretical model to be used in this study. The fifth section outlines and discusses the existing empirical knowledge on telehealth. The chapter closes with a summary.

Health Care Burden

The health care burden, summarized as the “Triple Aim,” (Berwick, Nolan, & Whittington, 2008), is the intricate balance needed between health, cost, and care. Not a new concept, the Triple Aim taxonomy serves as a call to order for healthcare researchers and policy-makers to compel and reinforce advancement in integrated care, or the means by which to address the health care burden. The first aim, health, references the overall health outcomes of populations. Cost, the second aim, is the per capita costs of care for populations. The third aim, health, refers to the individual's experience in the healthcare system and in receiving care. These are all inter-related concepts and therefore compel integration in health care (Berwick, Nolan, & Whittington, 2008).

The Triple Aim framework has been applied to various contexts in order to better systematize institutional efforts to improve health care systems around the world. Berwick, Nolan, and Whittington (2008) published a now oft-cited article in *Health Affairs* summarizing a taxonomy for how health systems can address the health care burden. While this article fell short of making prescriptions based on the Triple Aim, it has been a launching point for a variety of research projects on the integration of care (Valentijn & Goodwin, 2016; Whittington et al., 2015). To fill this gap, the Institute for Healthcare Improvement (IHI) took the triple aim framework to the global sphere and engaged 141 countries in a collaborative effort to further adapt the theory and coordinate health care system strengthening efforts as a result (Whittington et al., 2015).

The knowledge from studies stemming from Berwick, Nolan, and Whittington (2008) very clearly point to technology-enabled remote health care delivery as being in direct alignment with the direction of the Triple Aim in the integration of care. Integrated care and advancing the triple aim cannot be fully realized unless access gaps are addressed (Valentijn and Goodwin, 2016). Therefore, the health of populations can only be optimized when health care services are accessible. A main driver for telehealth at its premise is to reduce gaps in access to care within health care systems (Penchansky & Thomas, 1981; Peeters et al., 2008; Ranson et al., 2003). Penchansky & Thomas (1981) provide a model of "access" as consisting of five factors including availability, accessibility, accommodation, affordability, and acceptability. Health care, they assert, should be available, supported by enough skilled professionals and facility capacity to accommodate the demand reasonably. It should be accessible, such that those who seek healthcare services can reach them. Health care should accommodate different needs and patient requirements. It should further be affordable so that it is not prohibitive to those seeking care. Moreover, it should be acceptable in terms of the quality of care provided (Penchansky & Thomas, 1981). Telehealth seeks to increase access while reducing costs (i.e., travel, loss of productivity), and simultaneously maintain or enhance the quality of care. These five factors are facilitated by telehealth and can therefore lend directly to the infrastructure needed to support the strengthening of health systems.

Telehealth's capacity for providing avenues to improve the efficiency of health care systems makes it a viable option for communities in need of greater accessibility to health care. Rosenmoller, Whitehouse, and Wilson (Eds.) carried through the thought of e-health and its effects on integrated care in their organization of essays, *Managing eHealth: From Vision to Reality* (2014). The authors summarize that across the e-health domain, there are six (6) factors directly affecting integrated care, including supported self-management, delivery systems redesign, clinical information systems, clinical decision support systems, availability of community health resources, and a supportive health system. These factors infer that "support," or policy and infrastructure top-down influences, technology-supported decision-making, availability of knowledge to drive the technology, and a community foundation that values self-directed care would be instrumental in significantly improving the quality of health care. The rationale also assumes communal decision-making and an openness, and even desire, for individuals to be empowered to drive their own access to health care. Based on these findings on the connection of telehealth and how it may bring health care systems closer to the realization of the Triple Aim, it is evident that the application of technology in strengthening global health systems is a necessary next step.

The applications of telehealth have resulted in positive health outcomes. Piette et al. (2012) reviewed several independent e-health initiatives documenting the following outcomes: (1) text messaging health information and education improved care plan adherence rates; (2) a smoking cessation trial (n=5800) revealed that the percentage of smokers who quit nearly doubled after six months of the “txt2stop” mobile health intervention; (3) in low- and middle-income countries, it was noted that interactive voice response calls led to better self-care and physiological outcomes as well as positive health outcomes such as with glycaemia and blood pressure; (4) in a meta-analysis of 21 randomized trials of congestive heart failure patients (n=5715), the cost per patient was reduced by 300-1000 euros from remote monitoring compared to traditional methods of treatment. What Piette et al. (2012) found across these reviews and others, was consistent positive effects on population health with the use of telehealth applications from a variety of angles, including cost, patient perception of care, and health outcomes. These authors noted amongst the limitations in the literature, however, the lack of published studies that considered the integration required to fully assign a telehealth initiative as successful or sustainable.

History of Telehealth

Telehealth applications have progressed over time as innovations in technology and infrastructure emerged (Bashur and Lovett, 1977). First, with the telegraph came the opportunity to communicate casualty lists and order medical supplies during the Civil War. Later, when the telephone became available, physicians were among the early adopters for easing medical communications challenges (Zundel, 1996). During the 1920s, radio was used for verbal medical consultations (Winters, 1921) and by the 1930s, it was used to extend medical information transfer to help meet remote area access challenges (Bashur & Lovett, 1977). During war-time, such as World War I, World War II, or the Korean and Vietnam conflicts, radios were used to request and dispatch medical teams (Bashur & Lovett, 1977). Subsequently, when closed-circuit television was introduced in the 1950s, medical professionals began to leverage this technology for interactive video for remote patient visits as a way of resolving geographical access issues. Also, during this time, x-ray diagnoses were newly made via facsimile for engaging radiology expertise at a distance.

These applications resulted in positive outcomes of cost reduction, which would allow remote radiology to be "economically practicable" (Zundel, 1996). During the 1970s and 1980s, telecommunications were broadly diffused, which accordingly resulted in further experimentation and interventions using telehealth, primarily for remote health care services. Additional sophistication came with the focus on specialty care (e.g., psychiatry, cardiology, dermatology) as more awareness grew that telehealth was a viable method for diagnosis and treatment without sacrificing on components of quality care. These early applications of telehealth were mostly for remote medical services but have evolved today to include broader information exchange, consultation, and monitoring (Bashshur, Reardon, & Shannon, 2000).

Review of Reviews

As might be expected from a burgeoning body of literature, most early research focused on individual telehealth projects, the types of technology used, the costs of developing such a program, and the nuances of successes and failures (Bashur and Lovett, 1977). As research developed, more policy concerns were considered (WHO, 2009). Several scholars and institutions combined volumes of research to try and pull together differing perspectives on telehealth (WHO, 2009; Wootton et al., 2001). Systematic reviews of reviews were then conducted (Armfield et al., 2014; Yang et al., 2015). Now that there is a more robust body of literature, there is an opportunity to begin to generalize what contributes to adoption. What has not yet been observed is a large-scale view of state adoption and the potential reasons for success.

Between 1993 and 2012, the number of telehealth publications increased from 10 to 996, representing an over 9,000% increase in that 19-year period (Yang et al., 2015). This is an indication of telehealth becoming more of a concern for healthcare delivery systems (Yang et al., 2015). Armfield et al. (2014) conducted a bibliometric review and content analysis of 17,932 telehealth publication records between 1970 and 2013. In addition to also highlighting the rapid increase over time in attention to this field, they remarked a shift in the focus of the literature. Specifically, Armfield et al. noted the thematic shift in research focus from technical issues, such as the required computer systems and bandwidth needed to support telehealth, to more clinical concerns such as patient engagement, and population health outcomes. In that span, the core stabilizing theme was increasing access to health care services. An evidence base is an important factor in stimulating policy change and institutional readiness (Armfield et al., 2014) and, while telehealth research is growing, with much focus on specific cases of successes and failures of telehealth, it remains that the evidence base for its successful application is weak (Armfield et al., 2014).

Mair et al. (2000) evaluated the focus of telehealth studies and found that existing studies are limited and even "flawed" in focusing on the question of "Can we do this?" rather than "Should we do this?" Consistent with the thematic shifts observed by Armfield et al. (2014), Mair et al. found that the focus nearly two decades ago was more on using technology to solve a problem, rather than to identify the health care burden barriers and prescribing technology, or telehealth, as appropriate. Hakansson and Gavelin (2000) reviewed over 1,500 articles on telehealth and concluded that only 29 of those articles were substantive enough to assess the effectiveness of telehealth interventions. In this review, the authors identified the primary benefits of those findings were reduced travel and wait time for patients, yet only at a higher cost for the provision of care. Similarly, Gamble, Savage, and Icenogle (2004) summarized that the clinical effectiveness and educational benefits of telehealth are generally accepted principles across the literature. However, they further note the contrary findings as to the cost-effectiveness of telehealth. This points to lack of common measurement and possibly common definition of what constitutes successful outcomes. For example, does cost-effectiveness apply to the patient or to the provider or care? How is cost-effectiveness anchored, only by hard economics, or also by the positive health outcomes created by telehealth that may have implications on the total cost of population care? Common definitions across the literature can be a challenge to interpreting the literature and the effects of telehealth.

Quality research has been consistently identified as lacking in the telehealth literature (Demiris & Tao, 2005; Deshpande et al., 2008; Ekeland, Bowes & Flottorp, 2012). In response to debate about shortcomings in the methodological rigor of telehealth studies, Ekeland, Bowes, and Flottorp (2012) sought to systematically review the methodologies applied and the theoretical approaches used to assess the impacts of telehealth. Several key recommendations came from their qualitative review, including the need for more rigorously designed and controlled studies, standardization of populations and outcomes to better facilitate meta-analysis, and more mixed methods approaches rather than primary reliance on qualitative methods. In one quantitative example, Moser et al. (2004) also conducted a bibliometric review but focused on the number of telehealth publications per capita by state as the key metric. Moser et al. correlated publications per capita with the Human Development Index (HDI) ($r=-.60$), number of personal computers per 1000 inhabitants ($r=.73$), gross national product (GNP) per capita ($r=.69$), and population density ($r=-.12$). All correlations were significant with the exception of population density, indicating there is no relationship between the number of publications per capita and the size of a state's population. However, the significant relationships suggest that as the HDI decreases, the number of publications increases, yet as the number of personal computers and GNP increase, the number of publications increase. This raises some questions about what part of the human development index would cause an inverse relationship, which is not accounted for in the research. While it is beneficial to better understand some of the relationships between indicators explored, how that informs policy or adoption also remains of interest. It is a component of this research to help better synthesize the factors contributing to telehealth adoption.

Armfield et al. (2014) challenges the status of telehealth in its maturity in recognizing several factors for strengthening the telehealth literature. Primarily, Armfield et al. posit that formalizing the role of telehealth before it is implemented is of concern. That is, before trying to implement telehealth, it is important to assess the landscape for feasibility, efficacy and economics. These authors suggest that pushing out this relatively advanced technological approach to provision of healthcare services before an appropriate landscape assessment is made, increases the risk of implementation failure. To probe the timing and assessment of the conditions under which telehealth adoption is reasonable, Armfield et al. argue that more research in evidence-based telehealth is needed to guide decision-making on adoption. To take this further, it is suggested that primary studies aim for cohesion in results-gathering to facilitate synthesizing the literature, not only for generalization capability, but also to create a community understanding of best-practices that health systems, policy-makers, and practitioners can rely on. Lastly, Armfield et al. suggest that many telehealth failures go unpublished, while the successes are more frequently published. Indeed, this limits the knowledge base to factors that increase opportunities for success more often than lessons learned of contributions to failures.

Significance of the Study

"*Science has led to dramatic improvements in health worldwide. Yet all is not well. Disparities and inequities in health remain major development challenges in the new millennium, and malfunctioning health systems are at the heart of the problem. Half of the world's deaths could be prevented with simple and cost-effective interventions. But*

> *not enough is known about how to make these more widely available to the people who need them*” (WHO, 2004, pp. xv).

This statement published by the WHO captures the challenge telehealth diffusion confronts—making health care more widely available to more people. The aim is a simple one, yet a review of the literature on telehealth reveals multiple barriers to adopting this innovation aiming to close access gaps (Alkraiji, Jackson & Murray, 2013). States must confront the challenge of deciding from amongst the possible health care strengthening interventions, technologies and innovations with finite budgets, yet simultaneous goals of achieving the greatest level of health for the most people (WHO, 2015).

Global healthcare systems are shouldering increasing health burdens, requiring governments to adapt to the demands for human, financial, and institutional resources (Berwick, Nolan, and Whittington, 2008; Pew, 2014). A widespread definition of a “health system” is the one proposed by the WHO (WHO, 2009), “the organized social response,” whose main goal is to promote, restore, or maintain health. In 2007, with the purpose of promoting a common understanding about what a health system is and identifying action areas for the strengthening of health systems, the WHO prepared a framework made up of six building blocks as follows: “1) health service coverage, 2) health human resources, 3) health information systems, 4) medical products, vaccines and health technologies, 5) health financing, and 6) leadership and governance” (Pinzon-Florez et al, 2015). This framework observes the import of health information systems (i.e., electronic medical records, telehealth, and other information communication technologies). States are confronted with how best to support an institutional infrastructure that can keep the most people healthy and productive (Szreter & Woodcock, 2003). The overarching challenge is this: in the wake of population growth, aging populations, increases in the burden of non-communicable disease as well as communicable disease, and increasing quality standards (Rutherford, Mulholland & Hill, 2010), how can States best meet the health care needs of their respective populations while cooperating with other States globally?

Health care systems are governed in part by state actors and institutions (Duffield, 2007). In public policy concerns, most would claim to be interested in human well-being (Bates, 2004). Institutions are in place today to provide boundaries that facilitate a common understanding and are purposed for providing support to those who need it (Bates, 2004). Three major services provided by institutional healthcare systems are preventive services to limit exposure to disease such as sanitation and water conditions, preventive services for patients such as screening and immunizations, and general medical services for treatment of disease and injuries (Gupta et al., 2009). As such, States play a core role in the health of populations and provisioning for access of health care services.

Access to health care in both rural and urban settings is a world-wide challenge. Statchura & Khashanshina (2004) posit that "no nation can afford to replicate comprehensive healthcare resources in every large and small community" (pp. 6). One of the approaches to address the challenges in providing quality care to the most people, while balancing access, has been to leverage technology (WHO, 2009). Ouma & Herselman (2008) argue, in fact, that reliance upon information technology is the only way to maintain and improve healthcare systems. Innovation and technology are sources of social, political, and economic growth (Bates, 2004). In global health care, the Information Communication Technology (ICT) focus has been one that overarches such infrastructure development as big data and metrics, tracking of health outcomes, bandwidth expansion, electronic medical records, and telehealth (Wootton et al., 2009).

Telehealth is one innovative approach for facilitating access to health care (Wootton et al., 2009) and some may argue, the only economically viable way to stretch existing health care resources (Statchura & Khashanshina, 2004). Telehealth is not a stand-alone solution for systematically providing health care to populations. It is an adjunct to systems to help close gaps in access for primary and specialty care services (Schwamm, 2014). Telehealth facilitates: rapid dissemination of new discoveries; diffusion and adoption of common standards towards the aim of increasing the quality and delivery of care; support for and increased use of pharmaceuticals, diagnostic equipment and other health care-related tools, and; new clinical and specialty services (Statchura & Khashanshina, 2004). Benefits of telehealth include geographic access gaps closure, increased access to specialty care, better continuity of care, higher quality care, and more robust access to information (Gagnon et al, 2006). Community challenges such as loss of productivity, or time arriving at health care appointments (Grady, 2014), can be affected positively by accessing specialists who reside in mostly urban centers (Bergmo & Johannessen, 2006), and supporting more consistency in care plan adherence (Lindeman, 2011).

With all that is known about the benefits of telehealth and widespread public and private support (WHO, 2009), the diffusion (Rogers, 2003) of telehealth has still been surprisingly limited (Bergmo & Johannessen, 2006; Gagnon et al., 2003; van Dyk, 2014).

One of the major barriers to diffusion of telehealth throughout healthcare systems, is institutional infrastructure and the ability to absorb ICT innovation (Burwell & Saucier, 2013). Institutional readiness and solid-state healthcare system infrastructure are important factors to understand and put in place prior to investments in such innovations (Ravishankar et al., 2009). The cost of not understanding institutional variants influencing successful telehealth adoption is high.

Telehealth is a response to healthcare system short-comings in the management of population health (Peeters et al., 2008). Telehealth has great potential to support healthcare systems strengthening and the delay in its adoption delays effects on health care outcomes (Wootton et al, 2009). The WHO has recommended that Member States take steps to stand up telehealth agencies to help strengthen health systems (2009). Global health is a universal concern, as sustainable well-being drives abundant resource allocation. With state financial resources and social allocations central to growth and development (Ravishankar et al., 2009), this paper aims to further explore under what conditions successful telehealth adoption is optimized. It is valuable to understand how best to apply resources to yield more positive outcomes for more people to best address the global burden of disease (Ravishankar et al., 2009).

International Development is concerned with divergent paths of state development (Burchill et al., 2009; Toddaro & Smith, 2009), including human development (Sen, 1999), particularly the health of populations, as a major social factor influencing the well-being of nations (Kleinman, 2010). This research seeks to add to the understanding of system-level adoption of healthcare technology, and specifically telehealth, in contributing to human development. As it is broadly accepted that telehealth may serve as an important adjunct to existing health care but faces barriers to successful adoption, researchers have had limited input to the theoretical foundations that may explain this conundrum (van Dyk, 2014). Applicable theories that have been reviewed in the context of technology adoption and diffusion are the focus of the next section.

Theoretical Approaches

Broad Theoretical Foundations

The theoretical foundations for this research are next reviewed. Gammon et al. (2008) articulate that "in many ways, calls for theory resemble a field's search for identity as a science." Much of the theory that has developed to support the acceptance, diffusion, and adoption of telehealth has adapted existing theories in the social sciences (Gammon et al., 2008). Distinguishing the theoretical base specific to information technology in health care, and specifically telehealth, is a challenge to tease out and to establish a unique knowledge base within the field (Talmon and Hasman, 2002). Moreover, the absence of a cohesive framework or theory limits one's ability to validly predict acceptance and adoption of information technology and understand the relationships between influential variables (Cook et al., 2016; Davis, 1989). Herein, theories that have been applied to the understanding of telehealth are reviewed and the selection of the core theory to explore the central research question is discussed.

In 2008, Gammon et al. reviewed the common theories applied to telehealth studies to consolidate the theoretical groundings and infer the knowledge base available to the field. Gammon et al. reviewed 1615 articles, of which 5% discussed a theoretical concept (n=83). Using grounded theory, researchers categorized the theories and found that most of the shared theories (i.e., applied to telehealth research more than once) fell into categories of technology acceptance, health behavior, science and technology studies, economics, and diffusion.

Technology Acceptance. Technology, while it has the potential to enhance gains and improve performance across many domains, can only be as successful as the breadth of its use (Davis, 1989). Davis (1989) sought to better understand dissemination in his Technology Acceptance Model (TAM), in which the focus was on individual-level adoption. He sought to create a reliable and valid measure of predicting user acceptance of innovations in information technology and asked, "what causes people to accept or reject information technology?" Davis identified two variables: perceived usefulness (whether people believe a new technology will help them perform better), and perceived ease of use (whether the effort involved in using the technology is out-weighed by the benefits). Significant relationships were found between perceived usefulness and self-reported current usage (r=.63) and perceived ease of use and self-reported current usage (r=.45). This earlier work in establishing relationships with technology adoption served as a starting point for furthering this inquiry, yet clearly excluded several other explanatory variables such as compatibility (Rogers, 2003).

The Theory of Planned Behavior (TPB) is a robust and well-studied approach that extends from the field of psychology and has been often used to explain technology adoption (Cook et al., 2016). This theory holds that an individual's intention on whether they will display a behavior is the immediate predecessor to an action being carried out. TPB therefore suggests that people act in accordance with their intentions, though these intentions are not always static and may change depending upon individual preferences at the time (Azjen, 1985). This is an important consideration in understanding what drives successful telehealth diffusion because it posits that intentions have every impact on predicting technology adoption, or that internal intentions drive external behavior (Chu and Chen, 2016). External behaviors can also be influenced by a larger group or societal norm, which can feedback into individual preferences and intentions (Azjen, 1985; Chu and Chen, 2016). Here again, this theory focuses on the individual-level and group-level of analysis rather than the system-level of analysis. User acceptance was also reviewed by Werner and Karnieli (2003) in observing a relationship between patients and their physicians as well as their anxieties regarding technology. This relationship underlies additional individual acceptance influences.

Both the TAM and the TPB have been integrated by Venkatesh et al. (2003) into a Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT suggests that technology adoption is compelled by four factors: 1) performance expectancy, or whether a technology impacts quality of life; 2) effort expectancy, or whether a technology is easy to use; 3) social influence, or how opinion leaders view an innovation; and, 4) facilitating conditions, or individual beliefs that the infrastructure is available to support the new technology. Venkatesh et al. (2003) analyzed survey data across the afore-mentioned factors and identified a range of between 17 to 53 percent of the variance in user intention to adopt information. This model provides a fair, albeit not yet reliable, starting point for explaining the adoption of technology. It is clear, however, that there are several factors left from the model leveraging this theory.

Health Behavior. In addition to theories of individual intentions of adoption, is a related concept of the benefit of telehealth in its impact on health outcomes and behaviors leading up to better outcomes (Gammon et al., 2008; Zabada, Singh and Munchus, 2001). Theories here, again are grounded in the social sciences and focus on the behavior and cognition of individuals in the management and treatment of health care. This is a more disparate approach to understanding the adoption of telehealth in that there are many theories related to health-related behavior and, hence, the individual inclinations to adopt a technology that will lead to better health outcomes.

A core approach to health behavior is social cognitive theory, predicated on how individuals can successfully change their behavior to achieve desired health outcomes (Suter, Suter, and Johnston, 2011). Self-efficacy, according to Bandura (1977) is key in executing desired behaviors that will lead to certain outcomes, and the predecessor to behavioral change. Seydel et al. (1990) found that self-efficacy is a predictor of individuals' intentions to change their behavior for conducting breast self-examination as a preventive step for breast cancer and that individuals typically non-compliant with their self-care plans for chronic disease, can be compelled toward increased adherence with increased self-efficacy. It is the contention of this theoretical perspective that health care workers and institutions can influence the behavior of patients in the health care system to want to realize better health care outcomes.

Hsieh and Tsai (2013) looked at self-efficacy specifically as it pertained to the intention for adoption of telehealth in Taiwan. They found empirical support for a relationship between self-efficacy and the patient intention to adopt telehealth and summarized that because telehealth is a health service to patients, it is important to understand the behavioral modification needed to compel adoption broadly. Battaglia et al. (2016) specifically addressed whether telehealth could facilitate behavioral change.

Through the use of telehealth, the researchers administered motivational interviewing to see if smoking behaviors amongst a population of Veterans in the U.S. improved (*n*=178) when compared to a control group, who did not receive the telehealth-based treatment. The intervention group showed improvement in smoking cessation and authors acknowledged the impact of the use of telehealth in supporting behavioral approaches to treatment. These health behavior theories, again, are measured at the individual-level.

Science and Technology. This perspective probes the notion that science and technology are embedded in society and focuses on considerations requiring attention for successful implementation and adoption of innovation (Gammon et al., 2008). This grouping of frameworks looks at the interrelationships among social, political and cultural values. For example, Normalization Process Theory (NPT) assesses the social organization of implementation and how a new practice is realized in action; embedding, or how this new practice becomes part of the everyday way of doing things; and, integration or how the new practice becomes part of the larger institution or social matrix (May et al., 2009). This theory would apply to telehealth in observation of how social contexts and collective action undergird the promotion of a new practice and the integration of it to sustain the practice. This theory of collective action only represents a small portion of the picture of adoption.

The Actor Network Theory (ANT) holds that society is a network of both human and non-human actors and that network-building occurs through "translation" (Callon, 1986). Translation is how network-builders engage actors to support a particular interest or goal (Callon, 1986). In the instance of telehealth, this theory would suggest there is a translation path to successful telehealth adoption. In 2013, Afarikumah and Kwankam applied ANT to the study of a telehealth program in Ghana and found that, in the absence of cohesive networks, success of telehealth was limited. Here again, however, this theory is very narrow and is specific to social networking rather than broader institutional influences on telehealth.

Economics. Economic theories have been applied to the understanding of the benefits of telehealth (Gammon et al., 2008), while the economics of the adoption of telehealth only accounts for part of the story, given the additional theories previously described that have been predictive of adoption. However, it is important to acknowledge that the social networks, agents, and behavioral influences are well-supported by the demonstration that there is economic benefit to innovating in healthcare.

Cost analysis was applied to the study of telehealth programs in Arizona (U.S.) to understand the cost-effectiveness of eight rural telehealth sites (de la Torre, Hernandez-Rodriguez, and Garcia, 2003). The researchers found that the costs for telehealth visits for four of the eight sites exceeded the costs for traditional face-to-face visits owing to low utilization at those sites. This finding suggests that successful adoption should consider utilization and the relative advantage of the new telehealth services over the traditional method of healthcare delivery.

Cost-effectiveness assessment has also been applied to the study of telehealth (Agha, Schapira, and Maker, 2002). Telehealth, in this study, was compared to two other delivery methods for care: 1) the patient must travel from a remote location to the healthcare hub (e.g., the distance from the patient home to the hospital); and, 2) the patient receives care at a remote site (e.g., the patient receives care from a local clinic and does not need to travel to the hospital). Data was collected comparing these three delivery methods for one year. It was found that over that period, telehealth was found to be more cost-effective ($335 per patient/year) when compared to the patient traveling for care ($585 per patient/year) and the patient receiving care from a remote site ($1,166 per patient/year). Similar to the Arizona study discussed above, cost-effectiveness was impacted by utilization and authors summarized that telehealth is a cost-effective alternative to outpatient care. These economic considerations of the cost benefits of telehealth are but among the influences in successful adoption.

Diffusion. The most widely researched theory applied to the barriers to telehealth adoption (Gammon et al., 2008; Hillman and Schwartz, 1985; Walker and Whetton, 2002; Zhang et al., 2015) is *Diffusion of Innovations* (Rogers, 1962; Dearing, 2009). Diffusion research observes the evolution of processes over time as a function of the social system and considers social attributes that would impact the diffusion of an innovation (Rogers, 1962). This theory has the capacity to incorporate institutional considerations and can extend a broader framework to the central research question. It is worth noting that many of the considerations in the previously-reviewed theories find a home in diffusion research. For example, TAM's "perceived usefulness" can be paired with Rogers' observation of "relative advantage" or UTAUT's "effort expectancy" can be traced to Rogers' characteristic of "complexity." Of the theories presented in the relatively young body of telehealth literature, it is the Diffusion of Innovations that best applies to answering under what conditions telehealth adoption is most likely to be successful at the systems-level of analysis.

Diffusion of Innovation Theory

Diffusion of Innovation (DoI) theory focuses on the decision-making process leading to the adoption or rejection of an innovation (Rogers, 1962). Diffusion is regarded by Rogers as a societal-level function of social change, which is why this theory is appropriate to guide the research inquiry. Rogers (1962) put forth four components of his framework: 1) Communication, or how attitudes shape to support an innovation; 2) Time, or the speed to attitudinal change; 3) Social system, or how change agents and opinion leaders function to support the diffusion of the innovation; and, 4) Innovation, or characteristics that help explain the rate of adoption.

Communication. The communication characteristic represents how a mutual understanding of the effectiveness of an innovation shapes or changes attitudes towards the innovation. Diffusion is a type of communication and it is individual attitudes that are developed through communications networks that drive adoption. Communications channels can take many forms but ultimately serve to carry messages between individuals (Helitzer et al., 2003), particularly their perceptions and attitudes on the innovation (Rogers, 2003).

Time. The characteristic of time represents the speed to attitudinal change based upon the level of innovativeness of individuals, and speed to social system acceptance and adoption. Time describes differing speeds to uptake of technology. Rogers (2003) describes the speed of individual adoption by type: innovators, early adopters, early majority, late majority, and laggards. Innovators are those who rapidly adopt innovation at an average rate of 2.5% and are typically able to cope with the uncertainty of an innovation (i.e., have enough financial resources to absorb a possible loss). Early adopters (13.5%) are more integrated in the social system and are quicker to adopt the innovations. Early majority (34%) adopts before the late 50% of adopters. It is through this expansiveness to the social network the innovativeness can take hold. Late majority (34%) also comprises a large portion of the level of adoption and come in just after the average adoption rate. The innovation must be observed as favorable by this group before uptake. Lastly, laggards (16%) are suspicious of change and change agents and resist innovation and want to be certain that a new idea will not fail before adoption (Rogers, 2003). He further posits that there is a point of "critical mass," which is the minimum level of adoption that must be achieved for full diffusion to occur. Critical mass, according to Rogers, lies at the threshold of the early majority.

Social System. The social system characteristic represents the boundary within which a new idea diffuses. The social system is made up of "change agents" and "opinion leaders," described as key drivers of innovation (Helitzer et al., 2003). Change agents are active decision-influencers to either adoption or non-adoption of innovation. These change agents leverage opinion leaders to head the diffusion campaign. Opinion leaders function informally yet can influence attitudes and behaviors through the system's interpersonal communications network (Helitzer et al., 2003). Valente and Davis (1999) posit that much focus has been applied to interpersonal communications in the diffusion process but that understanding and tracing the influence of communications throughout social networks is really the key. Valente and Davis (1999) articulate the need for accelerating innovation diffusion by focusing on the contributions of opinion leaders. Of the factors most important in innovation diffusion, engagement of opinion leaders is perceived to be of utmost priority. How innovation is communicated, according to DoI theory, affects its diffusion and adoption.

Innovation. Of the four components to DoI theory, the innovations component will be the focus of this research. The innovation component of the framework focuses on the characteristics that help explain rate of adoption. Innovation is the most studied of the components of this framework of new ideas (Bertrand, 2004; Dearing, 2009; Peeters et al., 2012; Zhang et al., 2015). The innovation component goes further than much of the individual-perceptions theories on diffusion by looking forward to predicting the reactions to an innovation and how those reactions may compel a certain outcome. Rogers calls for a standard classification scheme to facilitate more common understanding of the perceived attributes of innovations and to further predictability and generalizability of innovations. He thereby puts forth five characteristics of the innovation component including relative advantage, compatibility, complexity, trialability, and observability (Rogers, 1963). Rogers describes these components as necessarily interrelated because they are social constructs but that they are conceptually distinct and therefore mutually exclusive.

First, relative advantage is “the degree to which an innovation is perceived as being better than the idea it supersedes” (Rogers, 2003). In the context of telehealth, one relative advantage might be health outcomes (Gammon et al., 2008), whereas if the innovation of telehealth does not create health benefits over and above the current healthcare delivery method, the relative advantage is dubious (Hillman & Schwartz, 1985). It would be expected that for successful telehealth adoption under this framework, relative advantage would need to be high (Civita & Dasgupta, 2007).

Second, compatibility is described as “the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters" (Rogers, 2003). Compatibility, as it pertains to telehealth adoption, is a characteristic that considers if the environment is ready for a technological innovation. For example, Alkraiji, Jackson & Murray (2013) researched a now widely implemented international healthcare information technology standard ("ICD-10") and observed the path to adoption. They found that overall infrastructure and financial support for that infrastructure were key barriers to adoption at the systems-level. In the absence of compatibility, telehealth adoption would be expected to be low.

Third, complexity refers to "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003). If telehealth is more difficult to adopt than traditional healthcare delivery methods, it is less likely to succeed (Peeters et al., 2012). For example, Keown et al. (2014) reviewed eight states (Australia, Brazil, England, India, Qatar, South Africa, Spain and the United States) to understand whether structural and organizational factors influenced the diffusion of innovation in health care. They found that organizational culture, context, and learning opportunities (i.e., having the learning opportunities to support the skill to support the innovation) were impactful in dissemination of innovations in health care.

Fourth, trialability is described as "the degree to which an innovation may be experimented with on a limited basis" (Rogers, 2003). This characteristic is representative of individual perception of an innovation and, as applied, references whether there is time to experiment with the innovation. Peeters et al. (2012) sought to better understand why some adopted telehealth support through a sample of home health elder and chronic care patients. They found that 62% of the variation in telehealth adoption was explained by relative advantage, compatibility, complexity, and observability, but they did not measure trialability as it is a characteristic difficult variable to measure reliably). Similarly, in this study, trialability has no available proxy or direct measure and is not included in the research model (further explained in Chapter III, Methodology).

Lastly, observability is explained as “the degree to which the results of an innovation are visible to others” (Rogers, 2003). This characteristic, when applied to the understanding of telehealth, observes whether the results of the innovation are visible to others (Helitzer et al. 2003). This characteristic would suggest that the easier it is to see the benefits or positive impacts of the innovation, the more likely they are to adopt (Peeters et al., 2012). In a systems-level study in the Netherlands, Peeters et al. (2012) reviewed the relationship between DoI innovation characteristics and found a significant relationship (α=.88) between observability and whether patients chose to adopt a home telehealth protocol. Rogers (1983) cites Thomas and Znaniecki (1927) in saying “If men perceive situations as real, they are real in their consequences.” Greater observability of telehealth would then suggest an increased opportunity for successful adoption.

It is acknowledged that the four components of DoI theory represent the full framework intended and put forth by Rogers (1962), yet this research focuses on the prediction of adoption and is therefore most suitably approached with a narrower focus on the innovation component and its characteristics. The communication and time components reference longitudinal experiences of potential innovators, which does not allow for a static assessment of the influencing factors in telehealth adoption while excluding the influences of historical factors. Further, the social system and measurement of the actions, beliefs, values, and influences of change agents, is a component that compels local-level measurement rather than systems-level analysis. The innovation component has been researched without the remaining three components when answering more specific research questions (Gammon et al., 2012). In this research, factors that influence telehealth adoption at the systems-level of analysis are of interest. Indeed, Rogers (2003) argues that innovations that propose greater relative advantage, compatibility, complexity, and observability are more likely to be adopted and with greater speed. The DoI framework and its innovation component, more than other theories, proposes a foundation to help answer this research question that is well-researched (Gammon et al., 2008; Hillman and Schwartz, 1985; Walker and Whetton, 2002; Zhang et al., 2015), has been applied to the study of telehealth and demonstrated applicability of DoI to the understanding of telehealth adoption (Helitzer et al., 2003; Patel and Antonarakis, 2012), and has been applied to system-level innovations research (Alkraiji, Jackson & Murray, 2013; Peeters, 2012; Rogers, 1983).

Previous Empirical Approaches

Herein, the major bodies of research will be summarized and assessed noting the different variables researchers have identified as having affected the adoption of telehealth. The relatively young telehealth literature groups readily into several focus areas (Wootton, 2009; WHO, 2010), one of which (theory, leading up to and including DOI) has been reviewed in the previous section. The remaining areas include applications (Zundel, 1996; Hersh et al, 2006), barriers (Bashur, 1995; Wootton et al., 2009), relative advantage (Lindemann, 2011; Rutherford, Mulholland & Hill, 2010), compatibility (Grady, 2014; Penchansky & Thomas,1981), complexity (Alkraiji, Jackson & Murray, 2012; Schwamm, 2014), and observability (Helitzer et al., 2003; Peeters et al., 2012). The proceeding review of literature in these areas will further compel the identification of independent variables that will be operationalized in Chapter III, Methodology.

Applications of Telehealth

The highlighted benefit of telehealth is that it extends a real opportunity for quality healthcare for anyone, anywhere, and at any time (Scott & Mars, 2015). It has been determined, however, that there are some conditions under which telehealth is not optimal from a cost or time investment perspective (de la Torre, Hernandez-Rodriguez, and Garcia, 2003). Under these conditions, one focus of the empirical telehealth research has been the application of telehealth including finding a common definition for what telehealth is, and from there exploring how telehealth is most optimally used (Hersh et al, 2006; Wootton et al, 2009).

Telehealth is designed partly as an alternative solution to patient health care for individuals who cannot readily access it at present. In traditional healthcare delivery, the patient experiences an ailment or proactively attends to their healthcare, makes an appointment, and physically visits with a healthcare provider to assess their wellness and obtain professional feedback for an applicable care plan. With telehealth, new options are created (Hersh et al., 2006): Telehealth is broadly observed as either synchronous or asynchronous (Moore, 1999). Synchronous telehealth services are real-time such as through virtual office visits, while asynchronous services are provided at different times, when the patient does not need to be available for interaction (Moore, 1999). More specifically, the telehealth industry can be organized into several classifications of health care services to include direct patient care, store-and-forward procedures, remote patient monitoring, and patient education and consumer health information. These broad classifications facilitate an understanding of how telehealth works in practice and in what healthcare system functional areas telehealth may help address access issues.

Direct Patient Care and Real-Time Visits. Reference to telehealth commonly connotes a real-time clinical visit that functions as a two-way synchronous communication between a patient at one location and a healthcare professional at another location (Wootton et al., 2009). The patient location is typically accompanied by a satellite healthcare professional who facilitates the visit for the patient and can also confer with the healthcare professional at the other location (Zundel, 1996). Some services provided during these visits include sharing audio, video, and medical data between the patient and healthcare professional. These help in the development of diagnoses, treatment plans, and advice.

A fully formed real-time capability would have a patient positioned in front of a computer/television screen with a camera while the remote provider is also in front of a screen and camera (Gagnon et al., 2006). This visit may also employ peripheral medical tools, such as a stethoscope, that allows for the remote provider to hear the patient's heart beat as though they are sitting in the room, or a small ear camera to see inside the patient earlobe with increased visual acuity owing to the advanced technical apparatus. In line with this, depending upon the complexity of the system elected, real-time visit capability could become expensive, especially where bandwidth and access to technology are a concern (Gagnon et al., 2006).

The application of direct patient care through telehealth can be examined in a tele-ECG ("ECG" means Electrocardiogram) program that was implemented in Norway as a means of early treatment for myocardial infarction (i.e., heart attack; WHO, 2009). As myocardial infarction has rapid onset with a short window for effective early treatment, this extended an opportunity for telehealth to be employed. Across Norway, telehealth equipment that supported real-time consultation with a remote cardiologist was installed in ambulances. This allowed response teams arriving at a patient's home to attend to the medical emergency immediately rather than delaying treatment until reaching the hospital. To aid in physician consultations, response teams were also able to capture and transmit ECG images for the physician review. This effort has resulted in the improvement of health outcomes by 15-20% for the population of patients who suffer myocardial infarction attended to by paramedics (WHO, 2009).

Taken together, these studies demonstrate the contribution of telehealth to more accessible health care, particularly to individuals who experience difficulty obtaining professional services due to incompatibilities and complications due to schedules and location. With telehealth, medical information, data, and advice are swiftly transmitted between patients and medical professionals. This resulted in improved health outcomes of individuals who can only avail of these medical services remotely.

Store-and-Forward. The asynchronous store-and-forward method used in telehealth is focused on the recording of patient information (i.e., store) and requesting of medical professional assistance for review and assessment of the information (i.e., forward; Hersh et al., 2006). This method may take the form of an encrypted email describing the patient background with attachments of image files such as for x-rays or lab results. While this does not allow for real-time consultation or interaction, it has been among the greatest successes to address access issues resulting from lack of qualified specialists to interpret patient results (Wootton et al., 2009). Store-and-forward methods are most widely used due to the low cost and simple technology requirements along with the health care impacts of obtaining consultation, interpretation, and advice more rapidly than possible using traditional methods of health care delivery (Wootton et al., 2009).

As an example of the store-and-forward method of telehealth, a teledermatology network (telederm.org) was created in 2002 by the International Society of Teledermatology to provide a worldwide online platform for teleconsultation services to discuss dermatological cases with emphasis on diagnosis and treatment. A secure connection was created for online subscriber access to the free service (Kaddu et al., 2009). The primary method of interaction with the service is through an online request for a consultation on a patient's dermatological condition; associated clinical images may accompany the request. Subsequently, the request is available for online expert opinion and feedback, overseen by a moderator. Over 1300 physicians in over 90 countries have subscribed to this store and forward service (Kaddu et al., 2009).

The WHO (2009) also documented the results of a telemedicine network that was launched in Mexico with the aim of screening over 1.3 million women for breast cancer between 2010 and 2012. Federal and State governments in Mexico invested in the necessary infrastructure such as access to radiologists, technology, and bandwidth. Thirty screening centers across Mexico were engaged in the store-and-forward program. This program was in response to a population health concern, whereby in 2006 breast cancer was the leading cause of death for women between the ages of 50-69. The approach led to increased access to the shortage of radiologists needed for breast cancer prevention, early diagnosis, and awareness (WHO, 2009).

Remote Patient Monitoring. Remote patient monitoring is a way of tracking patient health even while they are not present with a healthcare provider, typically through use of home devices. There are different levels of monitoring devices; from the simplest, which is the electronic messaging of a patient's vital statistics to their provider, to the more complex, such as heart pacemaker results automatically alerting medical professionals without patient intervention should there be any abnormalities recorded by the device (Zundel, 1996). One example is the widely popular alert system for elderly, whereas a press of a panic-button summons emergency medical help to the home on demand (Zundel, 1996). Patient monitoring has proven immensely useful for chronic disease management where daily or weekly care plan adherence is critical to a patient's health such as blood glucose and weight levels for diabetes, or blood pressure and heart rate for cardiovascular disease (Hersh et al., 2006). Depending upon the complexity of the home monitoring method employed, this approach could face the same technological barriers as real-time visits and be costly. However, this proactive monitoring can increase response time for diagnosis and treatment and have an impact on positive health outcomes of populations (Hersh et al., 2006).

Celler, Lovell & Basilakis (2003) reviewed a home-monitoring program for pulmonary disease patients. Patients were enrolled in a trial that asked at-risk patients to employ a home-monitoring device to record vitals (i.e., lung function, temperature, blood pressure) and these data were reviewed by a medical professional. In one case, the data patterns of a 58-year-old woman with pulmonary disease revealed an acute shortness of breath, which prompted medical intervention and a request to have the patient immediately admitted to the hospital. There, she was diagnosed with a lung infection and mild heart failure but, because addressed promptly, received the appropriate treatment and returned home within two days to resume care plan adherence.

Medical Education & Consumer Information. Medical professionals' ability to share and acquire information has been enhanced greatly with the introduction of telehealth (Wootton et al., 2009). Just as platforms have been created for continuing education, consultation, and mentoring amongst healthcare professionals (Zundel, 1996), consumers of health care are also able to receive more information via the internet, directly from their healthcare provider, or through peer support groups (Zundel, 1996). This educational opportunity for medical professionals and health care consumers is an inexpensive means of information sharing that can have positive impacts on health care outcomes, patient engagement, medical professional expertise, and communications regarding patient care. In 1995, the Shanghai Medical University launched its initial telehealth efforts, which commenced with the provision of remote education opportunities to the professional health care workforce. This system was used to allow for real-time teacher-student interactions, discussion, and learning, as well as for creating and housing centralized medical information resources (Chen & Xia, 2009).

Applications Summary. From the reviewed studies, it is evident that telehealth provides opportunities for patients to remotely access timely and good quality health care regardless of their time and location. These different delivery methods of telehealth are summarized consistently in the literature (Scott & Mars, 2015) and usher in conversations on their applications. Telehealth, with the various methods through which it is applied, speeds up the consultation process and response time from health care professionals, and facilitates health education for both patient and medical professional alike.

Telehealth applications have been increasingly explored over time and, accordingly, those applications that have realized the broadest use have been identified (WHO, 2009; WHO, 2016). In 2009, the WHO published a global review of telehealth adoption focused on the four most widely used applications of telehealth: teleradiology (medical imaging), telepathology (laboratory diagnosis of disease), teledermatology (skin conditions), and telepsychiatry (behavioral health). In 2016, the WHO cited these same top four areas as being the most oft-applied telehealth methods, but also added remote-monitoring. Between 2009-2016, the uptake in remote-monitoring outpaced the real-time method of teledermatology. Overall, there was an increase in the number of telehealth programs offered by WHO member states.

Table 1 *Percent of States That Reported a Telehealth Program*

	2009	**2016**
Teleradiology	62%	77%
Telepathology	41%	52%
Remote monitoring	n/a	47%
Teledermatology	38%	46%
Telepsychiatry	24%	34%
	n=114	*n*=122

These more frequent applications of telehealth notably line up with the foundational categories very well. For example, teleradiology and telepathology are store-and forward, asynchronous methods of delivery; remote monitoring represents its own category of recording information in real time to proactively be aware of anything that may signal intervention is needed; teledermatology may be either asynchronous (e.g., forward images of condition for consultation) or real-time (e.g., a patient conducts a virtual visit with the provider); and, telepsychiatry is real-time, synchronous. That these five top applications of telehealth coordinate well into the definitions of the delivery method, demonstrates a cohesion of the literature at this fundamental level. While there are many other applications of telehealth, the focus for this research is systems-level adoption, which compels a focus on broader, more often utilized approaches.

Barriers to Telehealth Adoption

A seminal work, Telehealth in the Developing World, was the first overview of the telehealth programs that have been implemented worldwide, successfully or unsuccessfully, with international researcher contributions (Wootton et al., 2009). The volume scanned the telehealth landscape, research, and future developments. Within this work, Wootton et al. reviewed best practices in telehealth adoption and summarized key criteria to include:

1. Physical access to technology.
2. Appropriateness of technology.
3. Affordability of technology and technology use.
4. Human capacity and training.
5. Locally relevant content, applications, and services.
6. Integration into daily routines.
7. Socio-cultural factors.
8. Trust in technology.
9. Local economic environment.
10. Macro-economic environment.
11. Legal and regulatory framework.
12. Political will and public support (Wootton, 2009, pp. 297).

These criteria are facilitated by institutions and the infrastructure they provide and are echoed across the telehealth literature (Berwick, 2008; Pinzon-Florez et al., 2015; Varghese & Scott, 2004); it is worthy to note these are also issues facing the broader context of healthcare systems (Berwick, Nolan & Whittington, 2008). These criteria are appropriately grouped and reviewed below:

Physical and financial access to technology. Technology underpins telehealth (Wootton et al, 2009). Particularly concerning real-time clinician-patient visits, it is important that bandwidth and connectivity are sufficient to fully maximize the benefits of telehealth (Steele & Lo, 2013). Often, access to technology is cited as an impediment to adoption, particularly in developing countries where communications infrastructure is insufficient (WHO, 2011).

The cost of technology is also often cited as a barrier to telehealth adoption (Bashshur, 1995; WHO, 2011). This is an interrelated concept to that of physical access to technology. Infrastructure to telehealth such as bandwidth, telehealth units, peripherals (i.e., electronic stethoscopes), computers, video cameras, speakers, and other associated devices are needed for proper delivery of services (Khan & Hayee, 2009). Acquisition of the components for telehealth comprises of a certain amount of expenses, but aside from that, sustaining the technology carries the expenses into the future, giving rise to concerns about the long-term return on investment for telehealth implementations (Bashshur, 1995).

Appropriateness of technology. In addition to the need for functioning technology, telehealth also reveals weaknesses of implementation when the right technology is not applied to meet the specific needs of healthcare system intervention

(Mars, 2009). For example, the store-and-forward method of using telehealth may be sufficient for radiology review but may be prohibitive to support any real-time patient visits.

In relation, appropriateness of technology is a concern pertaining to different areas and communities. Telehealth is a technologically-advanced solution to health care access challenges; however, in order for it to be effective, its content, applications, and services must be locally relevant (Wootton et al., 2009). Consequently, rural areas may or may not benefit from telehealth depending on technological readiness, human capacity in the local area, whether the immediate local needs are being met with the investment in telehealth (e.g., if polio eradication is of primary interest and can be readily addressed with existing health care delivery infrastructure, telehealth is unnecessary), or other factors (Einertz, 2001).

Human capacity and training. Human resources, in traditional health care delivery, are already constrained (Darzi & Evans, 2016; Statchura & Khashanshina, 2004). Meanwhile, telehealth creates an opportunity to reduce the burden of limited resources (e.g., by increasing access to specialty care most often located in urban centers), introducing additional technologies gives rise to a need for resources knowledgeable in the implementation, management, and utilization of those technologies.

Integration into daily routines. It is important that telehealth is effectively integrated into the general routines of the public. Wootton and Hebert (2001) argued that for telehealth applications to have a significant impact on medical practice, it needs to be thoroughly embedded into the previously established health care system. Otherwise, treating telehealth as merely an auxiliary component to the healthcare system creates a silo for the delivery of care that may increase cost and risk of patient care (Wootton & Hebert, 2001). Telehealth may be more fully maximized as a component of the way care is delivered for sustainability and long-term impact.

Aside from institutional means of integration of telehealth into the established practices in a community, legal means are also highly instrumental. The absence of appropriate regulations and legalities relating to telehealth significantly contribute as a barrier to adoption of telehealth, particularly because telehealth is used to deliver health care services and must conform to already-established institutional norms for quality, safety, and governance (Baker & Bufka, 2011). This is an interrelated concept to that of integration into daily routines described above. Institutions established to create support for patients and providers, with the introduction of telehealth, must also take care to ensure that its provisions align with those existing, and, if they do not align, must accordingly adjust or create laws and regulations (Dzenowagis, 2009).

Socio-cultural factors. There exist fundamental socio-cultural barriers to the uptake of telehealth (Peddle, 2007). In Nigeria, for example, there are cultural barriers to telehealth implementation such as taboos on the use of medicine or religious premises (van Gurp, 2015). Additionally, traditional health care delivery relies on in-person visits, such that there is some resistance to changing how health interactions occur using remote-access technology (i.e., looking into a camera and visiting with a clinician online) (Zhang et al., 2015).

Among socio-cultural factors that may be linked with the adoption of telehealth is a community's trust in technology when it comes to delivering health care. Rowe and Calnan (2006) revealed that the vulnerability associated with having an illness, and seeking out help as a result, is fundamental to the patient-provider relationship. Additionally, the trust required to close the gap on such vulnerability to evoke a clinician visit extends to relationships with the overall institution of health care such as organizations, hospitals, and governing policies (Rowe & Calnan, 2006). Layered on top of this already-observed need for trust in healthcare systems is the introduction of trust in a new technology to do what traditional health care delivery has done. While researchers have found that a generally accepting attitude toward telehealth as an alternative to the traditional health care model further encourages the adoption of telehealth (Fitzsimmons et al., 2016), areas or contexts in which individuals are not trusting or accepting of telehealth are less likely to witness successful adoption of telehealth.

Local economic environment. Related to the appropriateness and affordability criteria discussed above, local economic conditions and constraints may serve as barriers to adoption (Bashshur, 1995). As telehealth serves very specific access needs, the cost, risk, and benefits of adoption may not balance out to support local priorities (van Gurp, 2015).

Macro-economic environment. As telehealth can realize its greatest effects for developing and rural communities, it serves that underlying cost of adoption will accompany the weighing of its benefits against the other possible allocation of financial resources. Of concern at a macro level is whether states are applying financial resources within their healthcare systems that will realize the most benefit (Sridhar & Woods, 2013).

Political will and public support. State institutions are important to telehealth adoption, as incentives for clinician participation, other than participating in increasing access to care, are delivered through policy (Adler-Milstein, Kvedar, and Bates, 2014). Additionally, public support and demand drive telehealth adoption (Hardiker & Grant, 2011). Both public demand followed by political institutional support are needed to create a sustainable, integrated, effective telehealth solutions that contribute positively to existing healthcare systems. Technological innovation faces challenges of appropriateness and expertise, culture, technological discomfort, physician engagement, and relative advantage. Policy makers are influential in all of these areas and can help drive perceptions (Ediriuppulige et al., 2009). Political support is often also a requirement for institution-building, infrastructure investment, resource allocation, and developing policies for reimbursement (Duffield, 2007).

Barriers summary. A review of the literature shows that there are various factors that can become potential obstacles to the adoption of telehealth. These potential barriers can lie in the economic (e.g., economic environment, financial capability), socio-cultural (e.g., cultural norms and attitudes, trust in technology, daily routines), and political aspects (e.g., legal frameworks, policies). Most notably, these potential barriers can differ depending on the context or community in which telehealth is planned to be adopted. This poses a significant need to thoroughly assess the barriers in context before devising a plan on how to overcome them in order to achieve the successful establishment of telehealth.

Relative Advantage

State institutions are central in health care system evolution. Russell (1977) researched the adoption of five medical technologies by hospitals in the United States between 1953-1974. Data revealed that hospitals adopt technology at different rates, with larger hospitals adopting more quickly when the technology was more attractive than the existing standard. This finding demonstrates that there are differing rates of adoption and, accepting this premise suggests there are factors that may influence speed to adoption of telehealth. Zanaboni and Wootton (2012) aptly cite the differing rates of adoption during their first four years of availability of two now very standard medical technologies: Computed Tomography (CT) and Magnetic Resonance Imaging (MRI). A study conducted by Hillman and Schwartz (1985) showed that CT technology was much more rapidly adopted than MRI because of perceived "relative advantage," given the industry factors at the time of introduction versus those factors in place at the introduction of MRI. Innovation novelty, higher cost, and governmental regulation ultimately slowed the adoption of MRI despite its understood benefits. Consequently, Hillman and Schwartz summarize the "relative advantage" CT held to drive its diffusion was user demand. That is, the high cost, novelty, and overcoming government regulations for CT were acceptable conditions when compared to the risk of non-adoption in light of rampant industry demand (i.e., resulting in the ability to diagnose and treat patients while limiting invasive procedures). Observing these characteristics in the application of telehealth, the relative advantage must be perceived for its rate of adoption to increase (Hillman & Schwartz, 1985).

Although relative advantage may be evident, there may be cases wherein additional resistance may arise from simple health system inertia. Researchers have identified a few to include a lack of evidence or awareness of telehealth's benefits, prejudice against telehealth, and a lack of finances and expertise to implement it (Edirippulige et al., 2009). Similarly, large-scale health care reforms aimed at innovation in global health and better management of health outcomes have met with adoption challenges. One such example is in the case of common health data standards in Saudi Arabia (Alkraiji, Jackson and Murray, 2013). The researchers found that the effort for states to adopt global health data standards (ICD-10) and systems interoperability standards was intended to establish a common framework across health care systems to ensure patient safety, facilitate health systems delivery communications, coordinate care, and have better data accessible for health care analysis and reporting standards; however, it can inadvertently cause a delay in adoption of more modern medical and health care practices (Alkraiji, Jackson and Murray, 2013). This global standardization effort, while offering observable long-term benefits, still meets with resistance a decade after global acceptance of the data standards requirements.

The observable results of health care services are indicators of telehealth's relative advantage and are important for sustainability of adoption. As health care resources are often constrained (Ravishankar et al., 2009), investments into the system are accompanied with the expectation that there will be positive associated outcomes. Much research in telehealth focuses on whether telehealth provides a positive return on investment by way of supporting health system access goals over and above what may be achieved through traditional health care delivery and has demonstrated that care quality does not diminish as a result of the innovation (Bertrand, 2004; Celler, Lovell & Basilakis, 2003; De Civita & Dasgupta, 2007; Kaddu et al., 2009; Moloczij, 2015).

Child Mortality and Life Expectancy

Globally, child mortality has over time been reduced by targeted interventions in maternal and child health and improvements in overall health care quality. The WHO has identified child mortality as a leading indicator of the overall development of countries and the health of their populations (WHO, 2005). Similar to child mortality, life expectancy is also a major indicator of the health of populations. Life expectancy rates have over time highlighted the state of well-being of general populations and is used as a foundation for understanding allocation of resources, measuring the success of interventions, and longitudinally tracking overall population health (Robine & Ritchie, 1991).

Increased access to health care is an important driver for reduced child mortality, and telehealth targets this challenge in access (Rutherford, Mulholland & Hill, 2010). Policy interventions targeted at increasing access to health care services and enforcing the accountability of health systems have been cited among the underlying reasons for the reduction in child mortality rates (UNCF, 2011). As both life expectancy and child mortality are drivers in systems-level understanding of health outcomes, positive impacts created through telehealth may assist to shifting the perceived relative advantage (Rogers, 2003) of the innovation and therefore have an impact on the successful adoption of telehealth.

Communicable and Non-Communicable Diseases

Communicable and non-communicable diseases pose a threat to global health (NIC, 2002). The Global Burden of Disease Study (2016), sponsored by the Bill and Melinda Gates Foundation, sought to bring measured clarity to the understanding of the spread of communicable and non-communicable diseases. Analyses from this longitudinal data between 1980 to 2015 revealed overall decreases in communicable disease and heavy increases in non-communicable disease. From 1980-2015, deaths resulting from non-communicable disease (i.e., cancer, heart disease, dementias) rose 14.3% to 39.8 million deaths in 2015. During the same time period, mortality rates for communicable disease (i.e., HIV/AIDS, malaria) decreased approximately 2%. Furthermore, in 2015, communicable, maternal, neonatal and nutritional disease represented 20.2% of global mortality and non-communicable diseases accounted for 71.3% of deaths, with the remaining deaths attributable to injuries (8.5%). This data underscores the concern for attention to the rapid increase in non-communicable disease.

The WHO (2010) defines the aims of health systems as promotion, restoration, and maintenance of health; however, achieving these aims is made more challenging by the increased burden of disease faced by the health systems. While more robust strategies aiming for the prevention of these diseases are still underway, telehealth has resulted in positive effects for the health care of communicable and non-communicable diseases.

One contribution of telehealth is in its positive effects on one of the biggest cost drivers in health: hospital length of stay (Lindeman, 2011). The Veterans Administration (VA) in the United States (U.S.) implemented one of the largest telehealth programs in the world. The Veterans Administration (VA) was established in 1930 and was elevated to a cabinet level executive department in 1988. Initial health care services were only for the enlisted and for active duty-related injuries. During World War II, nearly 16 million eligible men were brought into the armed forces and it was after World War II that the VA formed a separate department for outpatient treatment for veterans not related to military service. This increased the scope of VA services in health care exponentially. With the large number of injured in the Vietnam war and the World War II veterans, the need for an extensive health care network mounted. Evolving to meet the needs of its growing population, the VA has worked to keep up with the needs of its members and grew to over 1300 sites of care nationwide, which made it difficult to meet the health care needs of millions of veterans and also manage increasing costs. By the mid-1990s, the VA was committed to exploring telehealth as a way to support the delivery of care (Lindeman, 2011). It was reported by Byrn et al., (2010) that “the potential value of the VA’s health IT investments is estimated at $3.09 billion in cumulative benefits net of investment costs,” after estimating financial return of the benefits being realized. In addition to the cost benefits, there has been increased patient satisfaction and reduced number of bed days (an indication of higher care quality), leading to reduction in institutional care for patients (Lindeman, 2011). Telehealth has further demonstrated its ability to facilitate chronic disease management, which for the United States, represents 75% of health care expenditures (CDC, 2016). Here again, any impact that telehealth may have to benefit the outcomes in communicable and non-communicable disease, may impact successful telehealth adoption and the corresponding perceptions of relative advantage vis-à-vis traditional methods of healthcare delivery.

Healthcare Expenditures Per Capita

Increases in health care expenditures per capita may impede or challenge the opportunity for investing in telehealth as part of the health system infrastructure and whether there is opportunity to impact those expenditures (Yip & Mahal, 2008). Researchers stress that it is important to remember that telehealth is not a stand-alone solution for systemically providing health care to populations. Rather, it is an adjunct to systems that help to close the gaps in access to primary and specialty care services

(Schwamm, 2014). Thus, it follows that there will naturally be careful consideration of a population's health needs against the benefits telehealth may provide while observing the cost of infrastructure development and innovation adoption as a portion of finite health care budgets (Manzini, 2015). As health expenditures as a percentage of GDP are finite and increase incrementally (WHO, 2016), governments and the institutions developed to support health systems and their strengthening therefore must prioritize budgets to drive the most public health good for the most people (Sridhar and Woods, 2013).

Aging Population

The challenge of aging, as it pertains to shifts in needs for health care resources, is relevant to understanding how to meet the demands of an increasing population and how telehealth may be considered for aid with this barrier (Burwell & Saucier, 2013). Mendelson & Schwartz (1993) reviewed these trends and summarized that persistence of the trend would cause rapid acceleration in health care costs, as the cost of treating patients over the age of 65 grows more rapidly than the cost of treating the population under 65. Data from the World Bank world indicators data base reveal an increase in the world population for individuals ages 65 and above as a percent of the total population. From 1995 to 2015, the population of individuals over the age of 65 rose from 6.45% of the total population to 8.26% of the total population. This represents a 28% increase in this population over the past 20 years. The population over the age of 65 is predicted to grow to 1.5 billion by the middle of the century.

Furthermore, according to researchers, the aging of populations is correlated with increases in high-cost patient populations with more complex health care needs that fundamentally require better coordination of care within health care systems (Burwell &

Saucier, 2013). Moreover, not only are populations aging, but they are also fundamentally growing so that the real number of individuals is increasing, and they are subsequently living longer, providing exponential opportunity for increased demand on health systems (Mendelson & Schwartz, 1993). This increased burden of disease lends to the concern over the need for increasing the share of GDP allocated to health (Pew Research Center, January 2014).

Synthesis. Relative advantage, or the extent to which an initiative is able to aid in the attainment of health care objectives in comparison to the existing system, is an important factor that must be present in determining the success of various technological innovations, particularly in the health care industry (Hillman & Schwartz, 1985). Past research has identified a number of persisting trends in the U.S. population that can serve as indicators of the effectiveness and success of various health care initiatives. Issues such as child mortality, low life expectancy, the spread of communicable and non-communicable diseases, and the continuous age gap in the American population still necessitate new solutions. There is evidence in the literature that through technological means, telehealth is a rather strongly supported solution. While it is still not able to singlehandedly eliminate these problems altogether, researchers have been able to identify unique ways in which telehealth aids in improving patient conditions despite these issues by reducing the issue of inaccessible health care (Rutherford, Mulholland, & Hill, 2010), lessening hospital costs and length of stay (CDC, 2011; Lindeman, 2011), and improving remote coordination between elderly patients and hospitals for monitoring and in cases of emergency (Burwell & Saucies, 2013). Despite this, there is still a lack of knowledge as to why telehealth is still not as widely adopted given the benefits that it has been shown to provide. Further studies regarding the factors that affect successful adoption of telehealth are still needed.

Compatibility

Compatibility, as reviewed by Rogers (2003), is concerned with whether a new technology can be easily accommodated into the context of its application. Technology should be applied to help meet human needs; however, it is often a mistake that new innovations emerge, and consumers adopt the innovation without fully vetting whether the innovation does what it aims to across all conditions (Wootton, 2009). Einterz (2001) aptly probes at whether institutions should first address basic human needs before taking a quantum leap into innovative technologies. She posits, "The development of costly high-technology solutions should not be an excuse to avoid the simple rolling up of sleeves and the dogged determination that are needed above all" (Einterz, 2001).

Einertz issues an important warning. Developing nations who observe the allure of telehealth as a possible 'quick-fix' to systemic health care infrastructure problems step into the position of applying technology to fix the need rather than letting the need drive the approach (Schwamm, 2014). Similarly, if access or expenses regarding telehealth are barriers in a particular context, successful telehealth adoption would be least likely.

Access. Historically, a major reason cited for barriers to quality health care for all has been access to traditional health care. Access can take on many forms, including geography (i.e., physically being able to obtain care), availability, or access to professional resources, and infrastructure, such as having bandwidth capabilities or a system design that fosters delivery gaps or disparities (Penchansky and Thomas, 1981). As telehealth positively affects many community challenges, such as loss of productivity time, arriving at health care appointments, accessing specialists who reside in mostly populated or non-rural areas, and supporting more consistency in care plan adherence (Bergmo and Johannessen, 2006; Grady, 2014), it can be inferred that telehealth would have high compatibility in contexts with common problems relating to access, thus making its adoption more likely. Patient satisfaction with telehealth services is also a benefit.

Rural Populations & Avoidance of Travel

As a primary function of telehealth is to increase access to care, it serves that physical access is a priority. The WHO, in the Health-for-All policy (1998), emphasized the importance of "reducing social and economic inequalities in improving the health of the whole population." It is the whole population for which state health care systems are responsible. Inequities can, in part, be attributed to access issues associated with rural populations and disproportionate health care resources located in urban centers (Ouma & Herselman, 2009). In response to the rural access challenge, telehealth and other ICT initiatives (e.g., electronic medical records and hospital information systems) have been implemented (Ouma & Herselman, 2009). In addition to the physical access challenges to care for rural communities are barriers of inadequate technical infrastructure (Steele & Lo, 2013), and attitudes towards shifting to leveraging technology (Gagnon et al., 2006; Moloczij et al., 2015) in rural areas as a response to closing care gaps.

A pronounced benefit of telehealth is the reduction in time required for both patients and health care providers to travel for face-to-face clinical visits (Grady, 2014). Wootton, Bahaadinbeigy, and Hailey (2011) researched the impact of telehealth, wherein they reviewed 20 teledermatology studies and their inferences of avoided travel. They reported a 43% reduction in travel in store-and-forward studies and a 70% reduction in travel overall with different modalities of telehealth, including real-time visits ($p<.014$). Offering telehealth thus begins to help solve for commuting challenges, such as loss of productivity time traveling to health care appointments (Grady, 2014) and access to specialists who reside in mostly urban centers (Bergmo & Johannessen, 2006).

Telehealth was shown to be compatible with common access problems as a survey of 3,000 adults revealed that 75% of respondents would be open to telehealth visits if it meant a reduction in travel time to a physician's office and greater convenience (Grady, 2014). Moreover, these findings relating to telehealth systems are aimed at both rural and remote health care, suggesting a reduction in the need to travel for both patient and care provider. A main driver for telehealth at its premise, is to solve for gaps in access to care within health care systems (Penchansky & Thomas, 1981; Peters et al., 2008; Ranson et al., 2003). Conversely, not meeting access targets with the implementation of telehealth points to a fundamental flaw in the application, execution, and sustainability of a telehealth strategy. Overall, it is likely that telehealth adoption will realize greater success if it can support closing access gaps to care.

Expenses and Financing

Expenses associated with healthcare are often barriers to adoption (Wootton, 2001). As reviewed, innovations in technology carry with them associated costs in infrastructure development, end user engagement, and the cost of training for and adoption of the innovation itself. This introduces additional considerations such as macro- and micro-level economies (Wootton, 2009), affordability (Ediriuppulige et al., 2009), and the mechanism(s) by which the health system reimburses care professionals for providing services under a new delivery method (Menachemi, Burke, and Ayers, 2003). In a survey of member states, the World Health Organization (2009) cited cost as a barrier to diffusion and sustainability of telehealth. Thus, understanding the burden of the cost of health care in rural and urban areas helps to reveal the cost burden to consumers (Yip & Mahal, 2008) and facilitate better understanding if cost is a barrier for these populations, and therefore a precipitating consideration for telehealth adoption.

Additionally, cost is a core component of the “triple aim” in health care to enhance patient experience, reduce cost, and improve population health (Berwick, 2008). A criterion for inclusiveness of innovation is complying with these fundamental foci in health care delivery and ensuring costs, quality and satisfaction are accordingly positively impacted. This is a broad indicator of telehealth success as effective cost depends upon the perspective of the stakeholder in the process. For example, cost-effectiveness may pertain to the whole of society, the patient, or to the health care entity provisioning the telehealth services (Yip & Mahal, 2008). Appropriate financing facilitates the incorporation of telehealth into an integrated care delivery system, which eliminates special funding needs.

An additional barrier cited across health systems references whether there are policies and procedures built into the health system design for reimbursement of telehealth services. As the services offered to patients through use of telehealth are the same as via traditional delivery methods, it serves that health professionals have the expectation of reimbursement for the same level of services (Menachemi, Burke, and Ayers, 2003). Experts believe that reimbursement policies are among the most influential variables for telehealth adoption (Menachemi, Burke, and Ayers, 2003). This was evident in Adler-Milstein, Kvedar, and Bates' (2014) study documenting the Information Technology Supplement to the American Hospital Association's 2012 annual survey of acute care hospitals. The results reveal that telehealth capabilities are available in 42% of hospitals in the United States. Moreover, larger hospitals with more resources and greater access to medical technology were more likely to have adopted those capabilities, but the major factor influencing adoption was respective U.S. state policies. The most influential policies were those regarding private payer reimbursement of telehealth services (Adler-Milstein, Kvedar, & Bates, 2014). Thus, it is expected that if cost effectiveness and the ability to pay is a real or perceived issue for a population, the chances of telehealth adoption success will be less.

Synthesis. The compatibility of any innovation to its context is composed of two components. For an innovation to be compatible with its context, it must be able to cater to the needs of the particular population (Schwamm, 2014; Wootton, 2009). At the same time, it should also be easily accommodated into the existing system. With both of these factors satisfied, an innovation is less likely to be adopted (Rogers, 2003). There is a general agreement in the literature that the same is likely to be true when it comes to telehealth. As some of telehealth's aims are to alleviate issues related to physical and financial access to health care, as well as to increase the time and travel convenience of the health care process for both patients and health care professionals, the adoption of telehealth is more likely to be relevant in a context with these same issues that telehealth aims to fix (Bergmo and Johannessen, 2006; Grady, 2014). At the same time, however, the factors that constitute as barriers to telehealth in a certain context must also be considered. One common barrier stated in the literature relates to the affordability of its implementation; whether it is attainable for the institution and for its stakeholders (Yip & Mahal, 2008). However, although literature has provided information on the factors that determine the compatibility of telehealth with a certain context, there is still a gap in the literature regarding the extent to which compatibility influences its successful adoption, if at all.

Complexity

Complexity is the extent to which an innovation is perceived as relatively difficult to understand and use (Rogers, 2003). Rural communities, while potential beneficiaries of telehealth services and, hence, increased access to care, often face infrastructural challenges. In particular, bandwidth and reliable telecommunications are needed to support delivery of telehealth technologies that facilitate the services (Steele & Lo, 2013). Telehealth initiatives reviewed in Kenya were met with resistance and lack of uptake due to poor infrastructure such as bandwidth and computers as well as personnel trained in the new technology (Ouma & Herselman, 2009). Similarly, understanding these infrastructural requirements, the Labrador Region of Canada adopted telehealth as a means of addressing workforce shortage and rural access issues. Significant investments were made to build up the telecommunications infrastructure and bandwidth in the region to undergird the telehealth implementation. Still, uptake of telehealth in Labrador was not as successful as planned, despite the financial investment in infrastructure, owing to issues of privacy, culture and trust. According to Rogers (2003), if telehealth is more difficult to adopt than traditional healthcare delivery methods, it is less likely to succeed.

Infrastructure. The inability of states to shoulder innovation is a very real constraint and institutions must first create a pathway for communications through infrastructure before looking to employ the technology it supports. One of the major barriers to shifting to increased access to more integrated, quality care is infrastructure, which influences the ability to adopt (Burwell and Saucier, 2013). Moreover, if institutions can successfully build supportive infrastructure, it remains that innovative technologies require individuals who are trained in their use (Ediriuppulige et al., 2009). Uncoordinated, unskilled attempts at implementing ICT solutions have been often cited as an issue (Dzenowagis, J., 2009). Alkraiji, Jackson, and Murray (2012) researched a now widely adopted standard (interoperable data standards globally) and observed the path to adoption for a common adoption of a healthcare technology standard globally. They found that overall infrastructure and financial support for that infrastructure were key barriers to adoption at the systems-level.

Information Communication Technology (ICT)

It has been widely documented that the barriers to telehealth adoption can be traced to the innovation of technology (WHO, 2009; Wootton et al., 2009). Technological advances, as a new health care delivery method, bring with them the need to have a supportive infrastructure by way of institutions and resources trained in the technology, as well as by way of ICT, such as bandwidth, internet, electricity, and hardware (Wootton et al., 2009). Introducing new technology meets with concerns of whether it is appropriately adopted given the health system design and constraints (Wootton, 2009), or whether there are skilled resources to drive the technological innovation (Ediriuppulige et al., 2009). Moser et al. (2004) conducted a study in which the number of telehealth publications were longitudinally correlated with the number of personal computers per 1000 inhabitants and a significant positive relationship was found (r=.73). This relationship demonstrates that there is a real relationship between increased use of technology and uptake of telehealth.

Healthcare Workers

The opportunity for telehealth adoption increases in complexity in the absence of a skilled or robust enough workforce. Skilled health care worker shortages may negatively impact the ability to deliver telehealth services (Liu et al., 2011). This is evidenced by the finding that shortages of specialists are often cited as barriers to health care access in rural communities (Ozuah & Reznik, 2004). A specific example can be found in the case of the non-profit organization, The Medical Missions for Children, provides services in 58 countries worldwide and, as of article publication, had provided over 18,000 teleconsultations annually, targeted specifically at children's health. The organization cites the high prevalence of under-5 child mortality rate and their aim to help reduce associated inequities in care. Disproportionately, those children residing in rural areas face inequities in health care, primarily owing to the shortage in pediatric specialty care. This phenomenon is not unique to developing countries. In the South Bronx, a medically-underserved borough of New York City, it is observed that children have increased prevalence of asthma and death. The Medical Missions for Children organization leveraged telehealth to increase positive health outcomes for the underserved population and also documented additional benefits of reduced time and distance barriers (Ozuah & Reznik, 2004).

The burden of aging populations naturally creates a demand for additional health care workers to meet the health needs. This demand is present amongst a simultaneous shortage of health care professionals (Peeters et al., 2012). Scarcity in health care human resources is a challenge (Wamala & Augustine, 2013) as there is a crisis in the availability of health care workers (Wootton et al., 2009). The WHO (2013) calculates that the world requires more than 4 million new trained health professionals to address this shortage, which impacts all countries, not just the lesser developed. Moreover, emigration of skilled health professionals to urban centers and/or developed nations (Statchura & Khashanshina, 2004) lends to disparities in rural health care (Bergmo & Johannessen, 2006). The inequitable distribution of health professionals among rural and urban areas creates more opportunities for health disparities, with 75 percent of doctors and 62 percent of nurses living in urban centers (WHO, 2013). This translates into major public health challenges. For example, each year over 48 million women give birth in the absence of a skilled health professional (UNICEF, 2011) and nearly 7 million children under the age of 5 die each year from preventable disease.

Synthesis. A review of the literature has established that individuals' perception that an innovation would be complex in terms of usability and understandability may contribute to difficulties in its implementation, thus lowering the likelihood of a successful adoption. As telehealth is a predominantly technological innovation in the healthcare system, complexity may significantly vary across contexts. Researchers have suggested that, in the case of telehealth, its complexity depends on the level of technological experience or adeptness as well as the attitudes toward the use of technology in health care that are embedded in a certain community or context (Steele & Lo, 2013). Moreover, there should be individuals who are capable of building and maintaining the necessary ICT infrastructure of the telehealth system, as well as enough workforce and resources to train them in the new telehealth services, in order for complexity to lessen (Ediriuppulige et al., 2009; Ouma & Herselman, 2009). With lower levels of complexity, a smoother transition and adjustment period and, eventually, successful adoption of telehealth is likely (WHO, 2009; Wootton et al., 2009). However, further research is needed to strengthen these findings on the association between these factors of complexity and the success of telehealth adoption.

Observability

Rogers (2003) describes observability as “the degree to which the results of an innovation are visible to others.” Attitudes toward innovation are expected to influence success of telehealth observability. This characteristic is perceptual in nature and requires human judgment as to the efficacy of an innovation to influence their acceptance. Certain values have been observed in telehealth literature to influence adoption, including trust in technology (Wootton, 2009) and observability or evidence of the benefits (Ediriuppulige et al., 2009; Patel and Antonarakis, 2012). It is reasonable that individuals hold interest in whether the technology delivers what it promises to. Zanaboni and Wootton (2012) reviewed the impact of user demand on telehealth adoption in Malaysia and summarized that the government could not lead the adoption of innovation by itself but needed to engage the end users of the technology to be successful. However, they found that user perceptions of the advantages of telehealth were not sufficiently positive to help drive adoption.

Schwamm (2014) likewise reviewed barriers to adoption of innovative technologies in health care and cited the aversion to “disruptive technology” as a key driver of such barriers. This concept dates back to the 1930s when Joseph Schumpeter introduced the notion of “creative destruction,” which is an essential process to advancing new ideas. Clayton Christensen later coined "disruptive innovation" as the early aversion to a new innovation despite its added advantage (Grady, 2014). Schwamm leveraged these earlier concepts as applicable to telehealth. He argued that telehealth is a disruptive technology in asserting its disruption to traditional methods of health care delivery, despite its documented potential for transforming the cost, quality, and access to delivery. This review yielded seven strategies for successful telehealth implementation including: "understanding patients' and providers' expectations, untethering telehealth from traditional revenue expectations, deconstructing the traditional health care encounter, being open to discovery, being mindful of the importance of space, redesigning care to improve value in health care, and being bold and visionary" (pp. 200). This is consistent with Zanaboni and Wootton's (2012) findings that user demand and willingness to adopt the innovation is key to successful adoption. This also demonstrates that there are real barriers to the diffusion of telehealth beginning with resistance to changing the health care delivery processes.

Perceptions. Socio-cultural factors play a large role in telehealth adoption (Wootton, 2009). It is the relevance of the technology that users perceive to help determine whether the innovation is applicable to the enhanced provision of services from what is currently available (Wootton, 2009). Understanding values and opinions that are generated from those values can help to better identify successful conditions for telehealth (Ekeland, Bowes and Flottorp, 2012). Public attitudes toward health care are important (Stokes, 2013). In an attitudinal-barriers study, Young et al. (2014) researched patient attitudes towards home-based health care information technology. Major themes emerging from their analysis to explain barriers to adoption included technological discomfort (including privacy concerns and distance from user representation) and lack of relative advantage and health system inertia.

Perceptions of Health Quality

As ICT develops further and telehealth becomes more broadly integrated, understanding of its use as well as buy-in by care delivery professionals will facilitate adoption. Clinician trust of telehealth and incentives to participate in its use are key in success (Ediriuppulige et al., 2009). Zanaboni & Wootton (2012) reviewed the impact of user demand on telehealth adoption in Malaysia and summarized that the government could not lead the adoption of innovation by itself but needed to engage the end users of the technology to be successful. Malaysia is among the few countries that have created institutional guidelines for governing telehealth as part of the health care system (Wootton & Tahir, 2004). The Malaysian government reviewed the evidence regarding benefits of telehealth and funded its implementation, shortly after which the project was closed down for re-evaluation. What they found was that user perceptions of the advantages of telehealth were not sufficiently positive to help drive adoption.

The application of telehealth in closing access gaps to stroke care was reviewed in Australia (Moloczij et al., 2015). For example, stroke is a leading cause of death and adult disability globally. Timely access to patients in remote or rural areas thereby creates a health system challenge since stroke requires timely response. As stroke treatment has improved over the years, this is an area in health care where outcomes may be positively impacted with increased access. In Moloczij et al., in-depth interviews with medical and nursing staff were conducted (n=24) to observe barriers to implementation. They revealed the primary barrier to be clinician trust in the efficacy of using telehealth as a viable stroke treatment response. Additionally, in a review of telehealth programs across Canada, Gagnon et al. (2006) observed that despite promising outcomes and adequate infrastructure, uptake of telehealth was limited. Physicians and health care managers were interviewed (n=54), in which they articulated better participation would result from clinician involvement in decision-making, adequate human and material resources, and a planned diffusion strategy. Perceptions on health are important to the current research based on findings that attitudes drive telehealth adoption (Zanaboni & Wootton, 2012) and how individuals feel about the importance of health care within their social structure can help to further illuminate openness to ICT.

Synthesis. Observability of an innovation is an important factor as it provides an idea of how effective innovation can be in a given context. An interesting finding within the literature is that Peeters et al. were able to establish a direction for the prediction of why some individuals adopted telehealth as a method of healthcare delivery and others did not. The survey administered by Peeters et al. pertaining to patient perspectives associated with DoI revealed the following factors: relative advantage (α=.78), compatibility (α=.83), complexity (α=.84) and observability (α=.88). These survey items were analyzed with principal component analyses to confirm the validity of the questions for each of the factors. In regression analysis, observability was a more significant predictor of telehealth adoption, yet all contributed to the variance of adoption explained (β=.62) (Peeters et al., 2012). This research helps to build on the literature in establishing a causal relationship between DoI characteristics and telehealth adoption.

In general, mixed findings were observed regarding the observability of telehealth and telehealth adoption. While some studies found that observable evidence of the effectiveness of telehealth positively influences adoption of telehealth (Ediriuppulige et al., 2009; Patel and Antonarakis, 2012), others found that the advantages of telehealth as observed by individuals was not sufficient to facilitate the adoption of telehealth (Zanaboni & Wootton, 2012). In line with this, there is a need for research to further clarify the relationship between observability and telehealth adoption.

Significance of the Research

Understanding the factors in predicting a successful path to telehealth adoption, and therefore successful outcomes (i.e., access to care, patient satisfaction, quality of care) can help to limit failed attempts and route resources to where they can be most effective. To this end, this research fills a gap in the existing literature by uniquely extending a systems-level view of state telehealth adoption including a probe into the associated factors of success. Launching this inquiry can validate common telehealth literature assertions, and further our understanding of how mature that literature is in identifying indicators that are predictive of successful telehealth adoption.

Specifically, this research quantitatively explores the application of DoI theory and its characteristics to guide an analysis of factors cited in the literature as being influential in successful telehealth adoption. Such an analysis has not yet been posed in this way. The gaps addressed through the central research question are several-fold. First, there is very little quantitative research that effectively measures the relationships between the indicators observed in the literature and their influence on telehealth adoption. Second, little research has been conducted at the systems-level, which will further aid in understanding the relationships between indicators and their influence on successful telehealth adoption. Third, DoI theory has been the theory most broadly studied in relationship to telehealth adoption, but the breadth of those inquiries remains limited and additional research will lend to this understanding. Lastly, results from the analysis may be beneficial in guiding additional policy considerations for what factors should be in place to increase the likelihood of successful telehealth adoption.

Chapter Summary

Recalling the health care burden as described by Berwick, Nolan, and Whittington (2008), the "Triple Aim" highlights the intricate balance needed between health, cost, and care. These goals have aligned with the promise of optimal telehealth adoption. Throughout the review and significance of the problem, theory, and the focus areas within the telehealth literature, there has been a synergy in the direction and conversation of the research that has helped to build support for the exploration of the research question: What are the main factors influencing successful telehealth adoption at the health care system level of analysis?

Table 2 *DoI Characteristic, Telehealth Literature, and Associated Indicators*

DoI Characteristic	Research Area	Variable
Relative Advantage	Health Outcomes	Child mortality rate under 5
		Life expectancy
		Health care expenditures per capita current US$
		Communicable disease cause of death as a % of total
		Non-communicable disease cause of death as a % of total
		Population ages 65+ % of total
Compatibility	Access	Rural population % of total
		Out-of-pocket expenses % total expenditure on health
		ICT Index
Complexity	Infrastructure	Number of physicians per 1,000 people
Observability	Perceptions	Human Development Index
		Perceptions of health quality

In the table above, it is rearticulated how DoI characteristics align with the bodies of knowledge on telehealth as supported by the literature and includes the indicators that further associate with those characteristics. Rogers (1983) posits that generalizations can be made from these characteristics “to predict the rate of adoption for innovations in the future” (pp. 213). However, despite the existing knowledge, there is still a need to quantitatively examine these factors in relation to the adoption of telehealth. The aim of this research, then, is to help answer the central research question through a quantitative probing into the factors that compel the DoI characteristic in explaining telehealth adoption. The next chapter, Methodology, summarizes the approach to addressing the research question.

CHAPTER III - METHODOLOGY

Introduction

The quantitative method (Wooldridge, 2009) applied herein was selected to most effectively target the research gaps noted in Chapter II (Literature Review), specifically in research at the systems level of analysis and in advancing the foundation for predictive analysis (Gammon et al., 2012). The key influencing variables on telehealth adoption have been reviewed, and this research seeks to next identify to what extent those indicators are predictive of successful telehealth adoption. Herein, the independent variables identified are mapped to those key indicators summarized by the relevant literature, and the selected dependent variables are the most broad and reliable systems-level measures available (WHO, 2015). In the quantitative approach, testing of hypotheses is afforded, generalization of findings can occur, random error can be controlled for, and biases can be more easily managed (Johnson & Onwuegbuzie, 2004). With the application of this method, this research may better add to the knowledge-base of which conditions telehealth predict greater viability of telehealth adoption. The quantitative method (Collier and Brady, 2010; Wooldridge, 2009) is specifically applied to help answer how much of the variance in telehealth adoption is explained by factors representing the Diffusion of Innovation (DOI) theory. Ordinal logistic regression is applied because there are five ordinal dependent variables and multiple continuous independent variables (Cohen et al., 2003). The outcomes of this analysis will yield greater insight into the generalizability of the proposed research model and aim to further illuminate the current understanding of what contributes to successful telehealth adoption.

The core research question to be addressed is as follows: What are the main factors influencing successful telehealth adoption at the health care system level of analysis? This analysis will contribute to understanding the conditions under which state health care systems are best poised to leverage telehealth as part of their system delivery infrastructures. The dependent (successful telehealth adoption) and independent (indicators of adoption) variables are measured at the systems level, applying DOI theory, and will help to better probe the understanding of whether there is a systems-level predictive model of successful telehealth adoption. The hypotheses to be presented and assessed are as follows:

H_1: Relative Advantage affects successful telehealth adoption.

H_2: Compatibility affects successful telehealth adoption.

H_3: Complexity affects successful telehealth adoption.

H_4: Observability affects successful telehealth adoption.

The DoI characteristics of innovation, namely relative advantage, compatibility, complexity, and observability, are represented in analysis by state-level published data. The dependent variables, state-level telehealth adoption, are directly measured by the World Health Organization (WHO) (2016). All variables representing the DoI constructs and the dependent variables are included in multiple regression analysis to assess predictability of telehealth adoption at the systems-level and further identify the best fitting model (Wooldridge, 2009).

This chapter will discuss the methods used in this study to examine the influence of the characteristics of relative advantage, compatibility, complexity, and observability on the adoption of telehealth. The methodology and its applicability to answering the research question will be explained and how the analyses will be conducted will also be detailed. This chapter is organized by first reviewing the dependent variables, their source and selection and how they are entered into the models for analysis. Subsequently, the independent variables will likewise detail the data sources, selection, and how they are entered into the model of analysis. Lastly, the regression equations are explained, and the methodological approach is summarized.

Dependent Variables and Measurement

The WHO, through its Global Observatory on eHealth (GoE), created a survey on e-health to better understand the level of engagement of member states and where they stand in development of their respective overall eHealth policies. The first survey was published in 2000, the second in 2010, and the third in 2016. While longitudinal, questions evolved over time, initially focusing primarily on telemedicine, and later adding more questions about eHealth, ICT, barriers, and additional formats for telehealth. Therefore, not all surveys are comparable since they sustained changes over time and, hence, the most recent data published in 2016 is used. The aim of the GoE survey is to better understand the role that eHealth plays in achieving universal health coverage, as the WHO contends that such coverage cannot be realized without the support of eHealth in both developed and developing states.

The GoE survey was web-based (using "LimeSurvey"), stored in a SQL, and then data was extracted using Excel. The controls for the web-based survey ensured only one response per state to prevent multiple entries, and all survey responses were translated into English subsequent to submission. Themes studied in the overall eHealth survey include mHealth, Telehealth, eLearning, Electronic Health Records (EHR), legal frameworks for eHealth, social media, and Big Data (WHO, 2016). For the purposes of these analyses, the questions pertaining to telehealth adoption are the focus. Specifically, Member States were asked to rate their respective telehealth programs based on whether they were “informal,” “pilot,” “established,” or “not applicable” because a program was not in place. An informal implementation is defined as: “early adoption of telehealth in the absence of formal processes and policies”; A program in pilot stage is defined as: “testing and evaluating the use of telemedicine in a given situation”; and, an established telehealth program is defined as “an ongoing programme using telehealth that has been conducted for a minimum of 2 years and is planned to continue for at least 2 more years” (WHO, 2016).

States were asked whether they had informal, pilot, or established telehealth programs in each of five areas: teleradiology (medical imaging), telepathology (laboratory diagnosis of disease), teledermatology (skin conditions), telepsychiatry (behavioral health), and remote monitoring (or any type of device-supported remote care monitoring).

Table 3 *Number of States Reporting a Telehealth Program by Type (WHO, 2016)*

Telehealth Program	**# Responses**	**%**
Teleradiology	96	77
Telepathology	65	52
Remote patient monitoring	59	47
Teledermatology	57	46
Telepsychiatry	43	34
Other telehealth initiative	55	44

Member states response rate was 64% (*n*=122). There is an observed difference between respondents, in that higher income and lower income states were more likely to respond than middle-income states. The WHO surmised that higher income states would be proud of their investments and lower-income states would be more eager to contribute any effort in this regard. This may represent a limitation in the representation for middle-income states, who likely had less progress in telehealth adoption. The survey did not assess local-level activity, but targeted state-wide response at the systems level of analysis (WHO, 2016).

The responses to the level of adoption in the five measured telehealth delivery areas are used to represent the dependent variable, successful telehealth adoption. That is, level of adoption (pilot, informal, established) for teleradiology, telepathology, remote monitoring, teledermatology, and telepsychiatry, each represent the five dependent variables in this analysis. Herein, using these variables to measure "success," address the central research question: What are the main factors influencing successful telehealth adoption at the systems level of analysis?

Independent Variables and Measurement

The independent variables have been identified from a review of the relevant literature presented in Chapter II. The measurable independent variables represent the constructs of DoI theory (Rogers, 2003). Each independent variable is included in analysis and all regressed on each of the five dependent variables previously defined. This analysis represents a logistic regression, as the dependent variables are categorical, and the independent variables are continuous (Cohen et al., 2003). Using the 122 states that responded to the GoE survey on telehealth (i.e., the dependent variable), data for all independent variables was thereby sourced for those same 122 states. Three data sources were used to include World Bank data, the United Nations (UN) Human Development

Index, and the Information Communication Technology (ICT) Index. After matching data based on state and removing missing cases listwise, the resulting sample size (n=84) is used in analysis. The independent variables are next described.

Table 4 *Independent Variables and Source Data*

DoI Characteristic	Variable	n	Data Year	Source
Relative Advantage	Child mortality rate under 5	84	2015	World Bank, 2015
	Life expectancy	84	2015	World Bank, 2015
	Health care expenditures per capita current US$	84	2015	World Bank, 2015
	Communicable disease cause of death as a % of total	84	2015	World Bank, 2015
	Incommunicable disease cause of death as a % of total	84	2015	World Bank, 2015
	Population ages 65+ % of total	84	2015	World Bank, 2015
Compatibility	Rural population % of total	84	2015	World Bank, 2015
	Out-of-pocket expenses % total expenditure on health	84	2015	World Bank, 2015
	ICT Index	84	2015	ITU, 2015
Complexity	Number of physicians per 1,000 people	84	2015	World Bank, 2015
Observability	Human Development Index	84	2015	UNDP, 2016
	Perceptions of health quality	84	2015	UNDP, 2016

Relative Advantage. This characteristic of DoI, when concerning telehealth adoption, considers the benefits to the health care system over and above traditional delivery methods (Hillman & Schwartz, 1985). Relative advantage can be measured by key health care concerns and on the basis of whether there is any positive relationship between successful state adoption and key population health indicators such as child mortality, life expectancy, healthcare expenditures, communicable and non-communicable disease, and aging populations. It is expected that there will be greater relative advantage, and therefore increase the chance of success with positive health outcomes in these key indicator areas:

1. Child mortality rate under 5: This independent variable serves as an indicator of the strength of health systems (Rutherford, Mulholland & Hill, 2010). The WHO has identified child mortality as a leading indicator of the overall development of countries and the health of their populations (WHO, 2005). Under-five mortality rate is reported by the World Bank for the same

122 state responders to the GOe survey for 2015. This variable is defined as "the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year" (World Bank, 2015).

2. Life expectancy: Life expectancy is commonly used to provide visibility into the health of populations, as longevity is an indicator of health (Yip & Mahal, 2008). Life expectancy is reported by the World Bank for the same 122 state responders to the GOe survey for 2015. This variable is defined as "the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life" (World Bank, 2015).

3. Health care expenditures per capita (current US$): This variable indicates if there are increases in health care expenditures per capita that may impede or challenge the opportunity for investing in telehealth as part of the health system infrastructure and whether there is opportunity to affect those expenditures (Yip & Mahal, 2008). Health care expenditures are reported by the World Bank for the same 122 state responders to the GOe survey for 2015. This variable is defined as "the sum of public and private health expenditures as a ratio of total population. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation" (World Bank, 2015).

4. Communicable disease (Cause of death as a percent of total): This variable tracks the burden of disease to better understand the opportunity for health system strengthening and what effects these burdens may have on the health system to pose barriers to telehealth adoption (WHO, 2010). Cause of death by communicable diseases (% of total) is reported by the World Bank for the same 122 state responders to the GOe survey for 2015. This variable is defined as "the share of all deaths for all ages by underlying causes. Communicable diseases and maternal, prenatal and nutrition conditions include infectious and parasitic diseases, respiratory infections, and nutritional deficiencies such as underweight and stunting" (World Bank, 2015).
5. Non-communicable disease (Cause of death as a percent of total): This variable tracks the burden of disease to better understand the opportunity for health system strengthening and what effects these burdens may have on the health system to pose barriers to telehealth adoption (WHO, 2010). Cause of death by non-communicable diseases (% of total) is reported by the World Bank for the same 122 state responders to the GOe survey for 2015. This variable is defined as "Cause of death refers to the share of all deaths for all ages by underlying causes. Non-communicable diseases include cancer, diabetes mellitus, cardiovascular diseases, digestive diseases, skin diseases, musculoskeletal diseases, and congenital anomalies" (World Bank, 2015).
6. Population ages 65+ (% of total): This variable observes the aging trend that will help to characterize the challenge of aging as it pertains to shifts in needs

for health care resources to meet the demand and how telehealth may be considered for this opportunity (Burwell & Saucier, 2013). Population ages 65+ (% of total) is reported by the World Bank for the same 122 state responders to the GOe survey for 2015. This variable is defined as "Population ages 65 and above as a percentage of the total population. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship" (World Bank, 2015).

Compatibility. This characteristic of DoI, as it relates to telehealth adoption, is concerned with whether a new technology can be easily accommodated into the context of its application (Schwamm, 2014). Telehealth will realize greater compatibility if it meets existing access gaps, such as for rural population, out-of-pocket expenses, or information communication technology (ICT) infrastructure.

7. Rural population (% of total): This indicator assesses what portion of the population may be geographically inhibited from accessing health care services typically located in urban centers and provides insight into breadth of health care disparities (Ouma & Herselman, 2008). Rural population (% of total) is reported by the World Bank for the same 122 state responders to the GOe survey for 2015. This variable is defined as "Rural population refers to people living in rural areas as defined by national statistical offices. It is calculated as the difference between total population and urban population" (World Bank, 2015).
8. Out-of-pocket expenses (% total expenditure on health): This variable observes the cost of health care in rural and urban areas to reveal the cost

burden to consumers (Yip & Mahal, 2008) and facilitate better understanding if cost is a barrier for these populations. Cost and consumer buy-in have been identified as a barrier to adoption to telehealth (Yip & Mahal, 2008). Out-of-pocket expenses (% of total expenditure) is reported by the World Bank for the same 122 state responders to the GOe survey for 2015.

9. ICT Index (ITU, 2015): The ICT Development Index (IDI) was developed initially in 2005 by the National Statistical Offices, Telecommunication Regulatory Agencies and Ministries, and Ministries, represented by 270 delegates in 85 countries. The index is comprised of indicators representing ICT infrastructure and access, ICT use by households and individuals, ICT use by enterprises, trade in ICT goods, ICT in education and ICT in government (ITU, 2015). ICT Index is reported by ITU for 112 of the same 122 state responders to the GOe survey for 2015. The index compiles an aggregate ICT development score at the state level from several factors to measure progress, the "digital divide," or the differences between countries in ICT diffusion, and future development opportunities. The individual measures aggregated for this index include:

    1. ICT Access (weighted at 40% of the index)

        a. telephone subscriptions per 100 inhabitants.

        b. mobile cellular telephone subscriptions per 100 inhabitants.

        c. international internet bandwidth (bit/s) per internet user.

        d. percentage of households with a computer.

        e. percentage of households with internet access.

2. ICT Use (weighted at 40% of the index)
    a. percentage of individuals using the internet.
    b. fixed-broadband subscriptions per 100 inhabitants.
    c. active mobile-broadband subscriptions per 100 inhabitants.
3. ICT Skills (weighted at 20% of the index)
    a. mean years of schooling.
    b. secondary gross enrollment ratio.
    c. tertiary gross enrollment ratio (ITU, 2015).

ICT "access," "use," and "skills" are the sub-indices to the overall index score, as they are all important factors in estimating the spread of ICT, including telehealth (ITU, 2015). Understanding level of education probes whether a work force is available to understand the innovations being produced and if education is keeping pace with the pace of the innovation itself. As education is identified in the literature as an influencing variable on telehealth adoption, and the ICT index includes a measure of education, this is importantly represented under the ICT index. The sub-indices were developed and normalized to support a common unit of measurement and a weighted average was taken for each (access=40%; use=40%; skills=20%) to aggregate into an overall index score.

Complexity. This characteristic of DoI, as it relates to telehealth adoption, is concerned with whether the innovation is too complex for the context within which it is applied (Rogers, 2003). Areas of concern for complexity include whether there are enough skilled health care resources to bring a systems-wide application to fruition.

10. Number of Physicians (per 1,000 people): The observation of number of physicians further explores human resources coverage (Liu et al., 2011). Number of physicians is reported by the World Bank for the same 122 state responders to the GOe survey for 2015. Physicians include "generalist and specialist medical practitioners" (World Bank, 2015).

Observability. This characteristic, when applied to the understanding of telehealth, observes whether the results of the innovation are visible to others (Helitzer et al. 2003). The UN Human Development Index and perceptions of health quality are used to proxy for this construct due to the measurement of real and perceived progress in health care development.

11. UN Human Development Index (HDI) (UNDP, 2016): The HDI is a tool used to help build on the data available to better understand the path for human progress in the area of Sustainable Development, specifically among the 193 Member States of the UN. The HDI is composed of consensus topics in sustainable human development and institutional reforms to achieve change in the direction of these aims. The HDI incorporates several components of human development to include: life expectancy, which represents longevity of life, mean years of schooling, representing the ability to acquire knowledge, and gross national income, to represent achievement of a certain standard of living (UNDP, 2016). The HDI is reported by the UNDP for the same 122 state responders to the GOe survey for 2015. Moser et al. (2004) correlated telehealth publications per capita with the Human Development Index (HDI) and found a significant relationship (r=-.60).

12. Perceptions of Health Quality (UNDP, 2016): The UN Human Development Report (HDR) has been published since 1990, with varying perspectives and data gathering foci. Consistently, the HDR has measured HDI yet has over time added additional measurements, all with the push of understanding the path to sustainable human development as well as the associated barriers. Among the additional data made available in the 2016 report (2015 data), a new table was added for supplementary indicators on the perceptions of well-being. The focus for the gathering of these supplementary indicators were individual perceptions of education quality, health care quality, standards of living, labor market, personal safety, and overall satisfaction with freedom of choice and life (UNDP, 2016, pp. 196). The perceptions of health care quality are included in the data model for telehealth adoption. Perceptions on health are important to the current research based on findings that attitudes drive telehealth adoption (Zanaboni & Wootton, 2012) and how individuals feel about the quality of health care within their social structure can help to further illuminate openness to ICT. Perceptions of health quality are reported by the UNDP for 116 of the same 122 state responders to the GOe survey for the like year, 2015.

Trialability. This characteristic is representative of individual perception of an innovation and, as applied, references whether there is time to experiment with the innovation of telehealth. Trialability is described as "the degree to which an innovation may be experimented with on a trialability limited basis" (Rogers, 2003). This characteristic of Rogers' DoI framework, however, is not included in the analysis because there is no ready measure for whether a society or its institutions have observed trialability of telehealth in a respective state. Peeters et al. (2012) conducted a study in the Netherlands to better understand why some adopted telehealth support. They found that 62% of the variation in telehealth adoption was explained by relative advantage, compatibility, complexity, and observability, but they did not measure trialability (as it is a characteristic difficult variable to measure reliably). Similarly, in this study, trialability has no available proxy or direct measure and is not included in the research model.

Quantitative Approach

The approach to summarizing the results is to first review descriptive statistics of the data and, second, to assess whether there is support for the articulated hypotheses. Descriptive statistics are helpful for understanding and summarizing the raw data and serve as the foundation for making inferences based on the data (Clegg, 1984). Descriptive data that will be presented in the results (Chapter V) will include case count (i.e., number of states), minimum and maximum values, means, and standard deviations, to assist with understanding the dispersion of the data and what the ranges are from one state to another. The descriptive data will be displayed for each of the DoI constructs and their respective proxy measures. For example, *n*, minimum, maximum, mean, and standard deviation will be summarized for the 6 independent variables representing the relative advantage construct. In addition, frequencies will be presented for the dependent variables to show the number of formal, informal, and pilot telehealth programs and how they are distributed for each of the five dependent variables (teleradiology, telepsychology, teledermatology, telepathology, and remote monitoring). This information is useful for understanding if there may be more formal programs (i.e., vis-à-vis informal or pilot programs) based on the different type of telehealth. Subsequent to presentation of the descriptive results, the hypotheses can be tested with regression analysis.

As described, there are four hypotheses representing each of the measurable DoI characteristics of innovation. Representing these characteristics are twelve measures that influence telehealth. The dependent variable is categorical and observes five measures of successful telehealth adoption. Ordinal logistic regression was selected because all independent variables are continuous, the dependent variables are ordinal, and because it estimates probabilities using a logistic function. The five logistic regression equations are as follows:

1. Ln(teleradiology) = $\beta 0 + \beta 1$ rural - $\beta 2$ outofpocket + $\beta 3$ ICT + $\beta 4$ childmortality + $\beta 5$ lifeexp + $\beta 6$ hcexpense + $\beta 7$ communicable + $\beta 8$ noncomm + $\beta 9$ age65 + $\beta 10$ physicians +$\beta 11$ HDI + $\beta 12$ healthqual + ε
2. *Ln(teledermatology)* = $\beta 0 + \beta 1$ rural - $\beta 2$ outofpocket + $\beta 3$ ICT + $\beta 4$ childmortality + $\beta 5$ lifeexp + $\beta 6$ hcexpense + $\beta 7$ communicable + $\beta 8$ noncomm + $\beta 9$ age65 + $\beta 10$ physicians +$\beta 11$ HDI + $\beta 12$ healthqual + ε
3. *Ln(telepathology)* = $\beta 0 + \beta 1$ rural - $\beta 2$ outofpocket + $\beta 3$ ICT + $\beta 4$ childmortality + $\beta 5$ lifeexp + $\beta 6$ hcexpense + $\beta 7$ communicable + $\beta 8$ noncomm + $\beta 9$ age65 + $\beta 10$ physicians +$\beta 11$ HDI + $\beta 12$ healthqual + ε
4. *Ln(telepsychology)* = $\beta 0 + \beta 1$ rural - $\beta 2$ outofpocket + $\beta 3$ ICT + $\beta 4$ childmortality + $\beta 5$ lifeexp + $\beta 6$ hcexpense + $\beta 7$ communicable + $\beta 8$ noncomm + $\beta 9$ age65 + $\beta 10$ physicians +$\beta 11$ HDI + $\beta 12$ healthqual + ε

5. $Ln(remotemonitoring) = \beta 0 + \beta 1$ rural - $\beta 2$ outofpocket + $\beta 3$ ICT + $\beta 4$ childmortality + $\beta 5$ lifeexp + $\beta 6$ hcexpense + $\beta 7$ communicable + $\beta 8$ noncomm + $\beta 9$ age65 + $\beta 10$ physicians +$\beta 11$ HDI + $\beta 12$ healthqual + ε

Using regression to answer the research question and assess the extent of the validity of the hypotheses lends value in several ways. First, it accounts for error (Wooldridge, 2012). This is important because DoI is a social construct and, in the social sciences, not all factors can be accounted for and measures as in a controlled experiment. Second, regression helps evaluate constructs and the relationships between constructs. This contribution is important to answering the research question, as better understanding the relationship between the constructs presented is the fundamental aim of this research. Third, this logistic regression method does not require a linear relationship between dependent and independent variables nor assume that the error terms are normally distributed (Wooldridge, 2012), which is again, beneficial for social constructs research. In analysis, logit is used to help with any specification issues or ordering in the dependent variable. Logit assumes standard logistic distribution of errors.

Conclusions

Applying this quantitative methodology contributes to developing a clearer understanding of the relationship between the factors influencing telehealth, described by the literature and expressed through DoI theory, and successful adoption. The methodology was driven by the research question: What are the main factors influencing successful telehealth adoption at the health care system level of analysis? As such, a review of the literature conveyed the key factors observed to influence telehealth adoption, and those factors were applied as independent variables in the analysis. The dependent variable, successful telehealth adoption by the five main types of telehealth, was represented by published WHO data. Since the dependent variable was measured by state (i.e., at the systems level), so too were the independent variables, sourcing published World Bank, ICT Index, and HDI Index data. With the inputs and structure of these variables, ordinal logistic regression is applied. In the next Chapter (IV), the results are presented.

CHAPTER IV – PRESENTATION OF RESULTS

Introduction

The purpose of this research is to understand more clearly what the institutional variants are in telehealth adoption. To focus this inquiry, quantitative methods were applied to analyze the indicators that telehealth literature generally suggests are influential in achieving successful telehealth adoption (Wootton, 2001). This chapter presents the quantitative results, adhering to the methodological approach previously defined (Chapter III, Methodology), and provides a foundation for analysis of those results in Chapter V, Analysis. Using published data sponsored by the World Health Organization (WHO), 122 states across the world have reported their status in telehealth adoption (WHO, 2016). For those same 122 states, the most recent World Bank data were accessed for the independent variables that have been identified in the methodology chapter to be most influential in driving telehealth adoption, in addition to human development index and perception of health data published by the United Nations Development Programme (2016), and data from the Information Communication Technology Index (ITU, 2015). With the application of this method, this research may better help to understand under what conditions telehealth adoption is viable. The research question considered is as follows: What are the main factors influencing successful telehealth adoption at the health care system level of analysis?

The following hypotheses served as the basis for the results to be presented.

H_1: Relative advantage affects successful telehealth adoption.

H_2: Compatibility affects successful telehealth adoption.

H_3: Complexity affects successful telehealth adoption.

H_4: Observability affects successful telehealth adoption.

Relative advantage, as it pertains to telehealth, is the difference between maintaining a traditional health care system delivery model and adopting a new method of delivery built on a new technological infrastructure and new clinical workflows (Hillman and Schwartz, 1985). Significance in the relative advantage construct equates to the extent to which telehealth is valued more than traditional methods of healthcare delivery, making adoption more likely. Compatibility is observable in review of the values and attitudes of potential adopters (Zanaboni and Wootton, 2012). Rejecting or accepting the null for the compatibility construct has implications for telehealth adoption based on whether the environment and existing values are accommodating of the change from traditional methods of healthcare delivery. Complexity in telehealth adoption is often cited as barriers in cost and infrastructure readiness (Alkraiji, Jackson and Murray, 2012; Schwamm, 2004). Significance in the complexity construct further illuminates whether infrastructure is a barrier to adoption. Observability owes to observable health care outcomes that can be directly linked to telehealth adoption within health care systems (WHO, 2009). Accepting or rejecting the null has implications for interpreting whether the ability to observe positive healthcare delivery predicts increased telehealth adoption.

Data Collection

The data used for this dissertation was gathered and provided for public use by the WHO. In 2005, the WHO adopted a resolution (WHA58.28) to develop an eHealth strategy for Member States (WHO, 2005). As a result of the resolution, WHO established the Global Observatory for eHealth (GOe), with a sole focus on the study of eHealth initiatives and their effects on health outcomes across state healthcare systems. As eHealth initiatives have been recognized as effective for global healthcare delivery and outcomes, GOe has sponsored a survey of Member States to track eHealth programs over time. The latest available data was summarized in the 2016 GOe Report.

Universal health coverage (UHC) is an effort supported by WHO Member States (n=192), who do not represent all states globally (n=195), but those who have determined to collaborate through the WHO. UHC was identified as a common aim rooted in the "belief that all people should have access to the health services they need without risk of financial ruin or impoverishment." The GOe sponsors a survey of all Member Countries that include nine themed sections, all contributors to the larger, eHealth field. One thematic section is specifically targeted to gathering state-level data on the adoption of telehealth (WHO, 2016). Of the 192 Member States, 122 responses to the survey were received (64%). However, missing data were excluded from the study. Thus, 38 responses were not included in the final dataset considered in the study. A total of 84 responses of Member States were included in the dataset.

Presentation of Results

The independent variables in the study are measures of relative advantage, compatibility, complexity, and observability. The independent variables that feature the characteristics of DoI theory are as follows:

1. Relative Advantage (*n*=84): Child mortality rate under five (World Bank, 2015); Life expectancy (World Bank, 2015); Health care expenditures per capita (World Bank, 2015); Communicable and non-communicable diseases

(World Bank, 2015); and proportion of the population over age 65 (World Bank, 2015).

2. Compatibility (*n*=84): Rural population (World Bank, 2015); Out-of-pocket health care expenses (World Bank, 2015); Information Communication Technology (ICT) Index (ITU, 2015), Human Development Index (UNDP, 2016)
3. Complexity (*n*=84): Physician Density (World Bank, 2015).
4. Observability (*n*=84): Individual perceptions of health quality (UNDP, 2016).

The dependent variable in the study is the successful telehealth adoption measured using the five disciplines of telehealth adoption. Each dependent variable is represented as whether it had 3=established, 2=pilot, 1=informal, or 0=not implemented telehealth programs at all. The five disciplines are:

1. Teleradiology, the electronic transmission of radiology images for diagnosis or consultation;
2. Teledermatology, the remote treatment of skin conditions;
3. Telepathology, the transmission of digitized images of cells for diagnosis or treatment;
4. Telepsychology, the remote treatment of mental health conditions;
5. Remote patient monitoring, or the transmission of health information from patient to provider.

Table 5 presents the descriptive statistics of relative advantage. Relative advantage is measured using six measures: mortality rate, life expectancy at birth, health expenditure per capita, cause of death being communicable, cause of death being non-communicable, and population of 65 and above. As presented in Table 5, the mortality rate of the countries is leaning toward the minimum value of 1.90 (M = 21.95, SD = 26.28). States with lowest child mortality are primarily in northern Europe, including Luxembourg (M=1.9), Iceland (M=2.0), and Finland (M=2.3). Côte d’Ivoire (M=92.6), Benin (M=99.5), and Botswana (M=114.7) have the highest child mortality rates in the sample. In terms of life expectancy, the mean value is at 74.51 years (SD = 7.32). Spain (M=83.4), Italy (M=83.5), and Japan (83.8), have the highest life expectancy rates and Côte d’Ivoire (M=51.0), Mali (M=58.5), and Zimbabwe (M=59.2) the lowest. For health expenditure per capita, the mean is between the minimum and maximum values of 2.60 to 11.90 (M = 7.22, SD = 2.25). States on the upper and lower ends of health expenditure per capita are Malawi (M=11.4), Switzerland (M=11.7), and Sweden (11.9) on the upper end, and Pakistan (M=2.6), Bangladesh (M=2.8), and Madagascar (M=3.0) on the lower. For cause of death being communicable and non-communicable, the results show that there is a higher percentage of non-communicable diseases as cause of death (M = 75.53, SD = 19.71). Finland (M=1.4), Hungary (M=1.9), and Bosnia and Herzegovina (M=1.9) have the lowest percentage rates of death from communicable disease in the sample, with the highest prevalence observed in Zimbabwe (M=57.3), Mali (M=59.9), and Malawi (M=60.5). Zimbabwe (M=29.7), Mali (M=30.5), and Malawi (31.2) have the lowest total percent of non-communicable disease, with the highest percent of non-communicable disease evident in Bosnia and Herzegovina (93.7), Greece (94.0), and Bulgaria (94.7). The results also show that an average of 10.74% (SD = 6.53) reach an age of 65 and above. Bahrain (M=2.4), Afghanistan (M=2.5), and Uganda (M=2.5) have the lowest average percent of the population over age 65, while the highest such proportions are evident in Greece (M=21.4), Italy (M=22.4), and Japan (M=26.3).

Table 5 *Descriptive Statistics of Measures of Relative Advantage*

	N	Min	Max	Mean	SD
Mortality rate, under-5 (per 1,000 live births)	84	1.90	114.70	21.95	26.28
Life expectancy at birth, total (years)	84	51.90	83.80	74.51	7.32
Health expenditure per capita (current US$)	84	2.60	11.90	7.22	2.25
Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)	84	1.40	60.50	16.34	17.41
Cause of death, by non-communicable diseases (% of total)	84	29.70	94.70	75.53	19.71
Population ages 65 and above (% of total)	84	2.40	26.30	10.74	6.53

Table 6 presents the descriptive statistics of compatibility. Compatibility is measured using three measures: rural population, ICT index score, and out-of-pocket health expenditure. Based on the results, an average of 35.78% of the total population in the sample is rural. States with the lowest rural populations are Singapore (M=0), Belgium (M=2.1), and Malta (M=4.6) and the highest percentages of rural population can be found in Malawi (M=83.7), Uganda (M=83.9), and Trinidad and Tobago (M=91.6). The ICT index score has a mean of 5.59 (SD = 2.21). The lowest ICT index scores in the sample fall with Ethiopia (M=1.5), Madagascar (M=1.5), and Malawi (M=1.6), and the highest ICT index scores are evident in the United Kingdom (M=8.8), Iceland (M=8.9), and Denmark (M=8.9). Out-of-pocket health expenditures are an average of 31.78% (SD = 16.31) of total expenditure on health. The lowest observed out-of-pocket health expenditures are evident in Botswana (M=5.2), Netherlands (M=5.2), and Oman (M=5.8) with the highest average expenditures in Bangladesh (M=67.0), Cambodia (M=74.2), and Sudan (M=75.5).

Table 6 *Descriptive Statistics of Measures of Compatibility*

	N	Min	Max	Mean	SD
Rural population (% of total population)	84	0.00	91.60	35.78	22.62
ICT Index score	84	1.50	8.90	5.59	2.21
Out-of-pocket health expenditure (% of total expenditure on health)	84	5.20	75.50	31.78	16.31

The complexity variable is measured using two measures: community health care workers per 1,000 people and number of physicians per 1,000 people. However, the state reports only include a few data points for number of community health care workers. Moreover, the existing data points for number of community health care workers were tested for correlation with the physician density. The results show a high correlation of Pearson's r = .64. Therefore, the analysis demonstrates that the number of community health care workers is correlated with physician density. For the complexity variable, only the measure of physician density is considered here. The descriptive statistics of physician density is presented in Table 3. The data show that there is an average of two physicians per 1,000 people (SD = 1.41). The lowest presence of physicians per 1,000 are evident in Malawi (M=.02), Ethiopia (M=.03), and Rwanda (M=.06). This indicates that there is not even one physician for every 1,000 people in those countries. The highest number of physicians per 1,000 people are in Norway (M=4.28), Greece

(M=4.38), and Spain (M=4.95), with approximately 4-5 physicians for every 1,000 people.

Table 7 *Descriptive Statistics of Measures of Complexity*

	N	Min	Max	Mean	SD
Physician density per 1,000 people	84	.02	4.95	2.11	1.41

Table 8 shows the descriptive statistics of measures of observability, as determined using two variables: human development index (HDI) score and healthcare satisfaction rating. Based on the results, the average HDI score is .75 (SD = .15). The HDI score is leaning toward the maximum score of .90, while the healthcare satisfaction rating falls approximately in the mid-range of the minimum and maximum values of 22 and 93. The lowest scores on the HDI are found for Mali (M=.4), Ethiopia (M=.4), and Côte d'Ivoire (M=.5), with the highest HDI scores observed for Australia (M=.9), Switzerland (M=.9), and Norway (M=.9). The average healthcare satisfaction rating is 58.55 (SD = 18.90), with the highest satisfaction rates evident in Denmark (M=88.0), Belgium (M=89.0), and Switzerland (M=93.0). The lowest healthcare satisfaction is evident in Sudan (M=22.0), Ukraine (M=22.0), and Mauritania (M=26.0).

Table 8 *Descriptive Statistics of Measures of Observability*

	N	Min	Max	Mean	SD
Human Development Index score	84	.40	.90	.75	.15
From HDI: Healthcare Satisfaction rating	84	22.00	93.00	58.55	18.90

The dependent variables are the telehealth adoption success variables measured using teleradiology, teledermatology, telepathology, telepsychology, and remote monitoring. The variables are measured using the following ordinal categories: N/A, informal, pilot, or established. The summaries of frequencies and percentages for each ordinal category are presented in Table 9. A majority of the countries have established teleradiology (n = 52, 61.9%), while many countries have no teledermatology (n = 35, 41.7%). Both high-income states and lower income states are observed in the "pilot" phase of teleradiology, including the United Kingdom and Pakistan, respectively. Similarly, both high-income (e.g., Norway) and low-income (e.g., Rwanda) states have "established" telehealth programs. For teledermatology, of those who have reached status of "pilot" or "established," there is a mix of state income profiles. For example, both Japan, a high-income state, and Zimbabwe, a low-income per capita state, are in the pilot phase of teledermatology adoption, while both Ethiopia (i.e., low-income) and Norway (i.e., high-income) have established programs.

There are also 31 countries (36.9%) without telepathology, with 23 states (27.4%) having established telepathology in their telehealth systems. States piloting telepathology programs in 2015 also ranged from low-income (e.g., Ethiopia) to high-income (e.g., Switzerland), with established telepathology programs found in states such as Uganda or Sweden. A majority of states do not have telepsychology (n = 48, 57.1%), while pilot programs are most often observed with high-income per capita states such as the United Kingdom, Japan, and Singapore. More states have remote monitoring in place (n = 49, 58.3%), and a majority of established programs are within higher-income states (e.g., United Kingdom, Sweden, Norway), though Afghanistan is one low-income state that also has an established remote monitoring program.

Table 9 *Frequencies and Percentages of Telehealth Adoption Success Variables*

		Frequency	Percent
Teleradiology	N/A	5	6.0
	Informal	11	13.1
	Pilot	16	19.0
	Established	52	61.9
	Total	84	100.0
Teledermatology	N/A	35	41.7
	Informal	11	13.1
	Pilot	13	15.5
	Established	25	29.8
	Total	84	100.0
Telepathology	N/A	31	36.9
	Informal	9	10.7
	Pilot	21	25.0
	Established	23	27.4
	Total	84	100.0
Telepsychology	N/A	48	57.1
	Informal	12	14.3
	Pilot	9	10.7
	Established	15	17.9
	Total	84	100.0
Remote Monitoring	N/A	35	41.7
	Informal	6	7.1
	Pilot	29	34.5
	Established	14	16.7
	Total	84	100.0

Regression Results

A priori sample size calculator called G*Power v3.1.0 was used to determine whether a sufficient number of samples was used in the study. Based on the result of the power analysis, considering 80% power, an alpha level of .05, and an ordinal logistic regression, a sample size of at least 25 was necessary for the study. The sample size needed for the study was 25 to have sufficient power to test the relative effects of the independent variables and dependent variables. The observations, or the actual number of states compiled to create the sample used for the study, is 84. Consequently, the sample of states in this study is sufficient to provide statistically valid results with at least an 80% power level.

To test the hypotheses posed in the study, ordinal logistic regression analyses were conducted. Each telehealth adoption success variable (teleradiology, teledermatology, telepathology, telepsychology, and remote monitoring) was considered as an individual dependent variable in the analysis. The independent variables, as grouped according to DoI theory, are entered into each of the five regression models, one for each dependent variable. These independent variables include child mortality, life expectancy, health expenditures per capita, non-communicable and communicable disease prevalence, population age 65+, rural population, ICT index, out-of-pocket health expenditures, physician density, HDI, and healthcare satisfaction. Prior to conducting the ordinal logistic regression analyses, tests for parallel lines were conducted to determine whether the assumption of proportional odds was violated for each of the analysis. Based on the results of the analyses, the tests of parallel lines were insignificant for teleradiology, teledermatology, telepathology, telepsychology, and remote monitoring. This indicated that the assumption was not violated.

For maturity of teleradiology, the results of the analysis are presented in Table 10. Based on the results, none of the independent variables are significantly related to the dependent variable maturity of teleradiology (p-value > .05). However, the overall fit of the model is significant (Chi-square = 25.172, p-value = .033). Therefore, overall, the combined independent variables are predictive of adoption, though, independently, the variables are not significant predictors, holding GNI per capita constant. States reporting no teleradiology program are diverse in nature including lower income states such as Cambodia and Zimbabwe, as well as higher income states such as Malaysia and Denmark. These regression results demonstrate that for these states, and despite the different income levels involved, there is no difference in predicting successful telehealth adoption across the four DoI constructs.

Table 10 *Logistic Regression Result for Maturity of Teleradiology*

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[Telerad = 1]	-8.543	16.883	.256	1	.613	-41.632	24.547
	[Telerad = 2]	-6.615	16.843	.154	1	.694	-39.628	26.397
Location	GNICap	.000	.000	1.041	1	.308	.000	.000
	ChildMor	-.003	.032	.009	1	.926	-.066	.060
	LifeExp	.016	.143	.013	1	.910	-.265	.297
	HEPerCap	.243	.206	1.391	1	.238	-.161	.646
	Commun	-.125	.145	.739	1	.390	-.410	.160
	NonComm	-.131	.140	.879	1	.348	-.406	.143
	Pop65	.088	.138	.409	1	.523	-.182	.358
	RuralPop	.004	.030	.017	1	.896	-.055	.062
	ICTindex	-.453	.695	.424	1	.515	-1.815	.910
	HDIindex	6.158	12.789	.232	1	.630	-18.908	31.225
	HCSat	.032	.028	1.327	1	.249	-.023	.087
	OPHExp	-.024	.034	.515	1	.473	-.091	.042
	PhysDen	-.854	.540	2.502	1	.114	-1.913	.204
Scale	GNICap	2.245E-05	1.255E-05	3.200	1	.074	-2.148E-06	4.705E-05

Link function: Logit. (Chi-square goodness of fit = 208.707, df = 142, p-value < .01)

For maturity of teledermatology, the results are presented in Table 11. The analyses show that rural population is significantly related to the dependent variable, maturity of teledermatology (Wald = 4.484, *p*-value = .034). Both HDI and population over 65 are approaching significance in the model (*p*-value < .10). The overall fit of the model is   insignificant (Chi-square = 20.166, *p*-value = .125). States with high rural population, such as Uganda (84%) and Ethopia (80%), have successfully adopted established teledermatology programs. These results would suggest that for states like Trinidad and Tobago, with no teledermatology program, yet high rural population levels (90%), there may be opportunity for successful adoption. Trinidad and Tobago also have a relatively high HDI (.8 of .9) and the population over age 65 (9.4%) falls close to the median (9.8%), thereby further suggesting, and according to the results, that this state may be poised for successful adoption of teledermatology.

Table 11 *Logistic Regression Result for Maturity of Teledermatology*

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[Telederm = 1]	12.763	26.213	.237	1	.626	-38.613	64.138
	[Telederm = 2]	15.148	26.342	.331	1	.565	-36.481	66.778
Location	GNICap	-3.517E-05	6.290E-05	.313	1	.576	.000	8.810E-05
	ChildMor	-.031	.053	.335	1	.563	-.134	.073
	LifeExp	.146	.236	.380	1	.538	-.317	.609
	HEPerCap	.757	.461	2.701	1	.100	-.146	1.660
	Commun	-.232	.268	.751	1	.386	-.757	.293
	NonComm	-.371	.278	1.783	1	.182	-.917	.174
	Pop65	-.488	.273	3.180	1	.075	-1.024	.048
	RuralPop	.187	.088	4.484	1	.034	.014	.361
	ICTindex	.484	.884	.299	1	.584	-1.250	2.217
	HDIindex	34.004	18.876	3.245	1	.072	-2.993	71.000
	HCSat	-.012	.038	.103	1	.748	-.088	.063
	OPHExp	.053	.053	1.008	1	.315	-.051	.158
	PhysDen	1.088	.796	1.865	1	.172	-.473	2.648
Scale	GNICap	2.007E-05	1.297E-05	2.396	1	.122	-5.345E-06	4.549E-05

Link function: Logit. (Chi-square goodness of fit = 319.518, df = 82, p-value < .01)

For maturity of telepathology, the results of the ordinal logistic regression are presented in Table 12. Based on the results, the ICT Index variable (Wald = 4.567, *p*-value = .033) is significantly related to telepathology. However, health expenditure per capita is approaching significance in the model (*p*-value < .10). The overall fit of the model is insignificant (Chi-square = 18.44, *p*-value = .187). While GNI per capita is held constant, state investment in ICT development remains a strong factor in predicting telepathology adoption. States with the highest ICT index scores also have established

Table 12 *Logistic Regression Result for Maturity of Telepathology*

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[Telepath = 1]	3.132	19.815	.025	1	.874	-35.705	41.969
	[Telepath = 2]	5.871	19.864	.087	1	.768	-33.061	44.804
Location	GNICap	-9.718E-05	5.741E-05	2.865	1	.091	.000	1.535E-05
	ChildMor	-.008	.037	.046	1	.829	-.080	.064
	LifeExp	.179	.180	.993	1	.319	-.173	.531
	HEPerCap	.477	.267	3.187	1	.074	-.047	1.001
	Commun	-.088	.187	.222	1	.638	-.454	.278
	NonComm	-.228	.186	1.506	1	.220	-.593	.136
	Pop65	-.165	.143	1.325	1	.250	-.445	.116
	RuralPop	.013	.036	.129	1	.719	-.058	.084
	ICTindex	1.719	.804	4.567	1	.033	.142	3.295
	HDIindex	-1.503	13.401	.013	1	.911	-27.768	24.762
	HCSat	.007	.028	.056	1	.813	-.049	.062
	OPHExp	.045	.035	1.595	1	.207	-.025	.114
	PhysDen	.250	.503	.248	1	.619	-.735	1.236
Scale	GNICap	8.611E-06	1.124E-05	.587	1	.444	-1.342E-05	3.064E-05

Link function: Logit. (Chi-square goodness of fit = 95.048, df = 90, p-value = .338) telepathology programs, including the Netherlands, Sweden, and Denmark. These same states also have higher healthcare expenditures per capita (10.9, 11.9, and 10.8, respectively) than the sample average (M=7.2).

Table 13 *Logistic Regression Result for Maturity of Telepsychology*

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[Telepsy = 1]	-32.329	32.996	.960	1	.327	-97.000	32.341
	[Telepsy = 2]	-29.839	32.718	.832	1	.362	-93.965	34.287
Location	GNICap	-1.028E-05	5.645E-05	.033	1	.856	.000	.000
	ChildMor	.056	.081	.475	1	.491	-.102	.214
	LifeExp	.008	.277	.001	1	.976	-.535	.552
	HEPerCap	.829	.583	2.023	1	.155	-.313	1.970
	Commun	-.754	.448	2.835	1	.092	-1.631	.124
	NonComm	-.711	.433	2.694	1	.101	-1.560	.138
	Pop65	-.028	.182	.025	1	.876	-.385	.328
	RuralPop	.033	.065	.253	1	.615	-.095	.161
	ICTindex	-3.552	1.934	3.374	1	.066	-7.342	.238
	HDIindex	56.365	33.238	2.876	1	.090	-8.781	121.510
	HCSat	.068	.050	1.799	1	.180	-.031	.166
	OPHExp	-.062	.055	1.260	1	.262	-.170	.046
	PhysDen	1.089	.711	2.345	1	.126	-.305	2.482
Scale	GNICap	4.079E-06	1.260E-05	.105	1	.746	-2.061E-05	2.877E-05

Link function: Logit. (Chi-square goodness of fit = 69.764, df = 56, p-value = .102)

For telepsychology, the results of the analysis (Table 13) determined that none of the independent variables are significantly related to the maturity of telepsychology (*p*-values> .05). However, several variables are approaching significance in this model, including Communicable Disease, Non-Communicable Disease, ICT Index, and HDI (*p*-value < .10). The overall fit of the model is significant (Chi-square = 31.34, *p*-value <.01). Singapore is one example of a state that may have a profile that leads to successful telepsychology adoption. Singapore has high communicable disease (21%, with a sample mean of 16%), high non-communicable disease (75%, with a sample mean of 76%), high ICT index (8.1 of the height of the sample range of 8.9), and HDI Index (.9 of .9).

For maturity of remote monitoring, the results are presented in Table 14. The analyses show that life expectancy (Wald = 3.886, *p*-value = .049), communicable disease (Wald = 4.698, *p*-value = .030), non-communicable disease (Wald = 4.920, *p*-value = .027), and ICT Index (Wald = 3.924, *p*-value = .048) are significantly related to the dependent variable maturity of remote monitoring. Both Child Mortality and Rural Population are approaching significance in the model (*p*-value < .10).

Table 14 *Logistic Regression Result for Maturity of Remote Monitoring*

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[RemMon = 1]	-14.894	31.561	.223	1	.637	-76.752	46.964
	[RemMon = 2]	-5.701	30.722	.034	1	.853	-65.916	54.514
Location	GNICap	-2.964E-05	6.910E-05	.184	1	.668	.000	.000
	ChildMor	.176	.099	3.158	1	.076	-.018	.371
	LifeExp	.940	.477	3.886	1	.049	.005	1.874
	HEPerCap	-.701	.568	1.525	1	.217	-1.814	.412
	Commun	-.863	.398	4.698	1	.030	-1.644	-.083
	NonComm	-1.032	.465	4.920	1	.027	-1.943	-.120
	Pop65	-.122	.232	.277	1	.599	-.577	.333
	RuralPop	.130	.074	3.098	1	.078	-.015	.274
	ICTindex	4.795	2.420	3.924	1	.048	.051	9.538
	HDIindex	-31.077	28.030	1.229	1	.268	-86.015	23.862
	HCSat	.061	.052	1.389	1	.239	-.041	.163
	OPHExp	.013	.062	.042	1	.837	-.109	.135
	PhysDen	1.969	1.349	2.129	1	.145	-.676	4.613
Scale	GNICap	2.411E-05	1.130E-05	4.555	1	.033	1.970E-06	4.626E-05

Link function: Logit. (Chi-square goodness of fit = 74.165, df = 82, p-value = .719)

In addition, the overall fit of the model is significant (Chi-square = 30.46, p-value < .01). These results suggest that a state with the profile of Panama has the potential for successful adoption of remote monitoring. With no current program, Panama has a life expectancy of 78% (above the sample mean of 75%), high prevalence of communicable (16%) and non-communicable (74%) disease, with an ICT index of 4.9 (of 8.9 at the highest end of the sample range). For Panama, this suggests it may be helpful to invest in ICT development to make remote monitoring a viable adoption option.

The outcomes of the series of logistic regressions are summarized in Table 15. Significant individual parameters are only noted for relative advantage and compatibility. The complexity and observability indicators are not significant. It is worth noting, however, that the HDI parameter, an indicator of observability, approaches significance for both teledermatology (p-value = .072) and telepsychology (p-value = .09). Also, the overall model fit values are significant for teleradiology (p-value = .033), telepsychology (p-value = .005, and remote monitoring (p-value = .005).

Table 15 *Summary of Analyses by Characteristic and by Dependent Variable*

			Model Fit Statistics				
			p=.033	*p=.125*	*p=.187*	*p=.005*	*p=.007*
DoI Characteristic	Reject Null ?	Variable	Teleradiology	Teledermatology	Telepathology	Telepsychology	Remote Monitoring
Relative Advantage	Yes	Child mortality rate under 5					*0.076*
		Life expectancy					0.049*
		Health care expenditures per capita current US$		*0.1*	*0.074*		
		Communicable disease cause of death as a % of total				*0.092*	0.03*
		Non-communicable disease cause of death as a % of total				*0.1*	0.027*
		Population ages 65+ % of total		*0.075*			
Compatibility	Yes	Rural population % of total		0.034*			*0.078*
		Out-of-pocket expenses % total expenditure on health					
		ICT Index			0.033*	*0.066*	0.048*
Complexity	No	Number of physicians per 1,000 people					
Observability	No	Human Development Index		*0.072*		*0.09*	
		Perceptions of health quality					

*significant P-value <.05

Conclusions

This chapter presented the results of the quantitative analyses applied towards furthering the understanding of the relationship between the factors influencing telehealth. Overall, relative advantage and compatibility characteristics show the best model fit and several individual independent variables support relationships identified in the literature. Life expectancy, communicable disease, and non-communicable disease were predictive of remote monitoring, as part of the relative advantage characteristic. ICT Index was also predictive of remote monitoring and telepathology, as part of the compatibility characteristic. Rural population, also in the compatibility characteristic, is a significant predictor of teledermatology. Further, there are numerous relationships that approach significance that are worth exploration. In the subsequent Chapter V (Analysis), these results and the implications of the results will be reviewed in further detail.

CHAPTER V – ANALYSIS

This chapter analyzes the results presented in Chapter IV (Presentation of Results), to include a review of the findings and according interpretation, as well as an analysis of how these findings relate back to the literature and theory. To recall, the purpose of this research is to better understand the indicators of successful telehealth adoption at the system-level of analysis. Quantitative methods were employed to identify to what extent the key indicators noted in the topic literature were predictive of telehealth adoption. Twelve indicators were grouped against four DoI characteristics (relative advantage, compatibility, complexity, and observability) and assessed against five different types of telehealth (teleradiology, telepathology, teledermatology, telepsychology and remote monitoring). The results showed that relative advantage and compatibility characteristics of DoI theory represent the best fitting model, and, in particular when applied to the successful adoption of remote monitoring. These results will be further explored and discussed below.

Analysis of Results

As described in Chapter IV, regression results were mixed and highlight the effects of relative advantage and compatibility as predictive of the dependent variables. In this section, these results are further analyzed and discussed in terms of the inferences that can be made. This section is organized to understand the results in the context of the dependent variables, and to interpret the implications of their respective model fit.

Teleradiology

Teleradiology is the most established of the measured forms of telehealth delivery. Among the sample, 62% of the states have established teleradiology programs.

The next most established type of telehealth is teledermatology (30%), or less than half of the established presence of teleradiology. The regression results show that measures of relative advantage, compatibility, complexity, and observability are not significantly related to telehealth adoption success in terms of maturity of teleradiology. However, the overall fit of the model, was determined to be significant (Chi-square = 25.17, p-value < .05).

States with very different indicator profiles can be established adopters of teleradiology pursuant to the data. For example, Rwanda is a low-income state and Spain is a high-income state according to the World Bank (2015), yet both have established teleradiology programs. Rwanda's physician density is .06 per 1,000 people, whereas Spain's is 4.95. ICT index for Rwanda is 2.0 (out of 10), whereas in Spain the ICT index is 7.7. Rural population is 71% in Rwanda against Spain's 20%. For states that look very different in terms of infrastructure, capacity, and need, both have successfully adopted suggesting that teleradiology is an accepted option for the delivery of radiology services in healthcare systems globally.

Teleradiology is the most widely adopted form of telehealth yet none of the DoI constructs and their representing variables are significant predictors of successful teleradiology adoption. This is a clear indication, then, that teleradiology is not considered an innovation and therefore does not represent the best model fit for the hypotheses. This is an important finding that underlines how DoI theory is only guiding the process of innovation adoption and diffusion. As such, teleradiology, the longest and widest implemented of the programs, is past its innovation stage. This helps to demarcate and establish clearly differences observed below in other types of telehealth. Moving forward, this finding is helpful for how and when to apply DoI to the study of telehealth adoption programs.

Teledermatology

Among the characteristics, the rural population indicator of compatibility was significant. This implies that if a state has an increase in rural population, the ordered log-odds of being in a higher category of maturity of teledermatology increases by 4.484. The measures of relative advantage, complexity, and observability are not significantly related to telehealth adoption success in terms of maturity of teledermatology. However, both HDI and Population over 65 are approaching significance in the model (p-value < .10), which are measures of relative advantage and observability, respectively.

This finding is relevant to furthering the understanding of telehealth adoption in that teledermatology represents a form of specialty care vis-à-vis primary or acute care. With the rural population indicator of compatibility significant, this suggests that the larger the rural population, the greater the likelihood of successful teledermatology adoption. In all, this finding suggests that specialty care such as teledermatology works well when the remote need is greater and, in particular, when the rural population is larger, since specialists mostly reside in urban centers. Those variables approaching significance include HDI, which lines up well with the expectation that a higher HDI would compel greater diffusion of a specialty care delivery method, and a growing population over 65. For example, Afghanistan, Ethiopia and Uganda have large rural populations 73%, 81%, and 84%, respectively and all have established teledermatology programs. The states that also have large rural populations, but no established program, do have either a pilot program or an informal program, suggesting states with these demographics may be well-poised for successful adoption (e.g., Zimbabwe, Madagascar, or Bangladesh). Ethiopia represents a good example of the significant relationship between rural population and teledermatology. Ethiopia has established programs in teleradiology and teledermatology as well as a pilot program for telepathology, but no telepsychology or remote monitoring. The rural population is at the higher end of the range of the sample at 80.5% and this is a significant predictor of the adoption of teledermatology. This type of remote specialty care may best benefit states with larger rural populations and supports the fundamental application of telehealth, which is to increase access to care.

Telepathology

Telepathology, or the laboratory diagnosis of disease, is represented by 27% of established programs in the sample. ICT index, a measure of compatibility, is significantly related to the maturity of telepathology. This implies that if a state has an increase in ICT index, the ordered log-odds of being in a higher category of maturity of telepathology increases by 4.567. None of the measures of relative advantage, complexity, or observability are significantly related to the maturity of telepathology, though healthcare expenditures per capita (a measure of relative advantage) approaches significance (p-value<.10).

The likelihood of successful telepathology adoption increases with a sound ICT index and, hence, more mature technology infrastructure. As telepathology relies on consultation and remote diagnosis, likely increased bandwidth is necessary to support such an exchange. States like Denmark, Sweden, and the Netherlands all have high ICT index rankings and have established telepathology programs. Other states without established programs but high ICT index include the United Kingdom and Mauritania. With both states in pilot stages for telepathology, the likelihood of successful and established adoption would be higher following this finding.

Telepsychology

Telepsychology is a behavioral health modality and most often is delivered through remote, synchronous, visits. The results show that measures of relative advantage, compatibility, complexity, and observability are not significantly related to telehealth adoption success in terms of maturity of telepsychology. However, communicable disease, non-communicable disease, ICT index, and HDI all approach significance (p-value<.10). These factors represent the constructs of relative advantage, compatibility and observability and suggest they may be influential in adoption. While not statistically significant (p-value<.05) these relationships suggest, the greater the prevalence of disease, the higher the ICT index, and the higher the HDI, the more likely the adoption of telepsychology. Singapore offers a good example of a state who may yet successfully adopt telepsychology, as the prevalence of communicable disease is 21%, the prevalence of non-communicable disease is 75%, the ICT index score is 8.1 (highest in range is 8.9), and the HDI score is high at .9 (out of .9). Indeed, Singapore is in the pilot stage for telepsychology.

Remote Monitoring

The constructs of relative advantage and compatibility are significant for remote monitoring. The measures of relative advantage that were found significant include life expectancy, communicable disease, and non-communicable disease, and the measure of compatibility found significant was ICT Index. This implies that if a state has an increase in life expectancy, the ordered log-odds of being in a higher category of maturity of remote monitoring increases by 3.886. This also implies that if a state has increases in communicable and non-communicable diseases, the ordered log-odds of being in a higher category of maturity of remote monitoring increases by 4.698 and 4.920, respectively. Moreover, if a state has an increase in ICT Index, the ordered log-odds of being in a higher category of maturity of remote monitoring increases by 3.924. The indicators approaching significance include child mortality rate under 5 and rural population, representing the relative advantage and compatibility constructs. Complexity and observability are not significantly related to telehealth adoption success in terms of maturity of remote monitoring.

Greece's outcomes are moderate across all forms of telehealth in that they have "informal" telehealth programs in place for teleradiology, teledermatology, telepathology, telepsychology, and remote monitoring. Greece has among the highest prevalence of non-communicable disease in the sample (94%), with a higher ICT Index (7.1 versus the highest score of 8.9), very low prevalence of communicable disease (3%), and higher life expectancy (81.6 years old). Greece's opportunity for successfully adopting remote monitoring, given the results, may be positive. Remote monitoring is an application suited for a solid technological infrastructure were non-communicable disease are high.

Norway is one of the richest countries in the sample (GNI=$93,560), has high physician density (4.28 per 1,000), low child mortality (2.6 per 1,000), low communicable disease (7%), high life expectancy (82.1 years), high ICT Index (8.5), yet high non-communicable disease (87.3%). Norway has established programs in teleradiology, teledermatology, and telepsychology, and an informal program for remote monitoring, though no program reported for telepathology. With the exception of higher prevalence of communicable disease, Norway would be well-poised according to the model for a formally adopted remote monitoring program.

Literature and Theory Alignment

This research represents an early attempt at generalizing influential telehealth indicators at the state level and has promising indications for future research in this regard. Ekeland, Bowes, and Flottorp (2012), in their systematic review of methodologies in telehealth, called for additional contributions to facilitate meta-analytic research for better understanding telehealth relationships. Rogers (1962) put forth a framework for innovation that fit this inquiry and lent to organizing the quantitative analysis of the central research question. Diffusion of Innovations theory observes the evolution of processes over time as a function of the social system and considers social attributes that would impact the diffusion of an innovation as well as the decision-making process leading to the adoption or rejection of an innovation (Rogers, 1962). What the analyses here imply is that telehealth is to be considered an "innovation" more so for burgeoning applications of telehealth (i.e., remote monitoring) rather than established applications (i.e., teleradiology). In particular, Rogers' DoI theory for the innovations characteristic, helps explain telehealth adoption through the components of relative advantage, whether an innovation is perceived better as the traditional method, and compatibility, or whether the environment is ready for innovation. This suggests that need, and perception of value to fill that need, as well as whether the environment is prepared to absorb the change are the two key factors in predicting success of innovative applications of telehealth. For established telehealth, however, DoI theory offers only minimal explanatory power.

With the new understanding that "innovation" does not universally apply to all forms of telehealth just because it is a relatively newer way of delivering healthcare, it remains that some findings are not as expected, even for the innovative form of telehealth, remote monitoring. Findings in the literature would suggest a stronger role for HDI in predicting remote monitoring telehealth adoption, as Moser et al. (2004) found a significant positive relationship between number of telehealth publications per capita and HDI (r=-.60). However, HDI was not a significant predictor of remote monitoring. Moser et al. similarly found a significant relationship between number of telehealth publications and number of personal computers per 1000 inhabitants (r=.73), one of the components of the ICT Index. In this model, the relationship between ICT Index and remote monitoring is significant (*p*-value <.05).

Three indicators (out of pocket health expenditures, healthcare satisfaction, and physician density) held no predictive ability for any of the dependent variables and lent no support to any of the hypotheses. (Lindeman, 2011; World Bank, 2013; Zanaboni & Wootton, 2012). Since these variables are observed in the literature as influential in telehealth, it is worthwhile to explore potential reasons for these deviations from expectations. First, a common barrier stated in the literature relates to the affordability of its implementation and whether it is attainable for the institution and for its stakeholders (Yip & Mahal, 2008). Increases in health care expenditures per capita have the opportunity to impede or challenge adoption of telehealth as a result. The out-of-pocket expenses, or the cost burden to consumers (WHO, 2009), while observed to be a potential barrier to adoption does not carry out in these analyses as a predictive variable. One possible explanation is that out of pocket health expenses may already be implied in the states with successful telehealth adoption, since many telehealth programs are initially publicly funded, or receive funding support from institutions, and therefore often have mechanisms for reimbursement (Menachemi, Burke, and Ayers, 2003). Thus, where out of pocket expenses may be a consideration, because telehealth requires institutional investment and change agency, many programs take care to eliminate the consideration of cost before taking on a telehealth program, rendering expenses to individuals already controlled for.

Second, healthcare satisfaction also carried no predictive power as an indicator of observability. Perceptions on health have been often cited in the literature as being influential in telehealth adoption (Lindeman, 2011; Zanaboni & Wootton, 2012). How individuals feel about the importance of health care within their social structure is expected to have a relationship to openness to telehealth adoption. Lack of explanatory power for healthcare satisfaction may reflect on the prioritization of considerations for telehealth adoption, such as relative advantage and compatibility. For example, if telehealth can remove barriers to traditional healthcare delivery such as increased access to care to achieve better health outcomes, like child mortality, this consideration may carry more weight than whether there is satisfaction with the healthcare system as a whole. Therefore, attitudes about healthcare delivery at the systems level may not be as influential as other indicators as previously thought.

Lastly, physician density offers no explanatory power for any methods of telehealth adoption. Physician density is suggested in the literature as a very strong factor in the evaluation of telehealth adoption (Liu et al., 2011; Ozuah & Reznik, 2004; Peeters et al., 2012; Wamala & Augustine, 2013; WHO, 2013; Wootton et al., 2009). In effect, having enough skilled health care workers to facilitate traditional healthcare delivery is already a fundamental challenge and it was expected that the adjunct of telehealth would further burden the existing availability of physicians. A possible explanation for lack of influence of physician availability is that fundamentally, telehealth adoption is addressing access issues, not increasing workforce issues. Therefore, a state may opt for telehealth adoption because it is compelled by the relative advantage of what health outcomes can be achieved for their populations more than solving for worker shortages. Under this model, states are willing to adopt telehealth whether or not there are physician shortages.

Generally, the barriers to telehealth adoption cited in the literature act as expected in the model, taking into account this is an exploratory model to determine the best fit. One clarification to the literature that can be added as a result of the hypotheses tested herein, is that, for innovative applications of telehealth, the DoI theory applies best in the areas of relative advantage and compatibility and these areas supersede practical concerns such as expense, satisfaction, and physician density. Yet, for the remaining indicators reviewed, all functioned in the direction expected and as purported in the literature, though some factors were more influential than others.

Key Findings

The implications of the results have been reviewed, as has been the alignment with theory and literature and, from this analysis, there are three key findings. First, more established forms of telehealth no longer constitute "innovation." Second, remote monitoring is an innovation and is well-represented by DoI theory, providing the best-fitting model. Third, relative advantage and compatibility are the core drivers of telehealth adoption in this research. These findings are important to advancing the literature, as there was sufficient power to support the inferences that can now be drawn from the predictive models.

An interesting finding culminating from the analysis of results is that more established forms of telehealth no longer constitute “innovation.” Recalling the foundation of DoI theory, its intent is to focus on the decision-making process leading to the adoption or rejection of an innovation (Rogers, 1962). Diffusion is regarded by Rogers as a societal-level function of social change, which is why this theory was selected to guide the research inquiry; it lines up well with the central research question, as to the conditions of successful adoption of telehealth. What the results show, however, is that for the most widely adopted types of telehealth, the predictive model that is comprised of literature-infused indicators does not hold.

Teleradiology, for example, is the most widely adopted application of telehealth though none of the predictors were individually significant. The social change that is a prerequisite for the explanatory power of DoI therefore does not apply, meaning that teleradiology is no longer viewed as an “innovation” once it reaches a certain level of saturation. It is unclear at what point a new technology ceases to become an innovation. However, this finding suggests that not all forms of telehealth can be treated equally when subject to analysis, which is an important contribution to this field of literature, as often different types of telehealth are compared to one another.

In addition, teleradiology is a store-and-forward, or asynchronous, telehealth delivery method. As technology has advanced such that real-time, synchronous, options are becoming increasingly prevalent in how we communicate generally (e.g., Skype meetings or "Facetime" phone chat visits), asynchronicity likely is observed as less of an innovation and more of an operationalized version of how things can be done to achieve desired outcomes. In the instance of telepathology, both real-time and store-and-forward methods can be used. And in this case, ICT index was a significant predictor of telepathology, suggesting that additional information communication technology infrastructure is important to supporting the exchange. Where ICT index makes no difference to teleradiology adoption, this suggests that teleradiology is not perceived as an innovation because it does not require additional technological support than what can already be institutionally provisioned.

Another key finding is that the best-fitting model is for remote monitoring, which is an innovation, and is well-represented by DoI theory. To recall, for remote monitoring, the parameters significant in the model include life expectancy, communicable disease, non-communicable disease, and ICT Index. The indicators approaching significance include child mortality rate under 5 and rural population. These observed relationships align well with what would be expected given the literature. This suggests that for applications of telehealth that are more complex, new to market, or still in their burgeoning stages of diffusion, the model is best-fitting.

Remote monitoring can be both synchronous or asynchronous but is increasing in rate of adoption, given its relative advantage and the compatibility with conditions. In the sample, nearly 35% of the remote monitoring programs were in pilot stage, with nearly 42% counting as “n/a.” The remaining 23% have informal or established programs. This is the profile of both large opportunity and large interest. No other form of telehealth has as large of a pilot group, suggesting this is the upcoming form of telehealth to be institutionalized. As other forms of specialty telehealth begin down their path to adoption, this finding will guide understanding the expected rate of successful diffusion.

A third important finding is that relative advantage and compatibility are the core drivers of telehealth adoption in this research. The DoI theory and the innovation component of the theory were the focus of this research. The innovation component of the framework focuses on the characteristics that help explain rate of adoption and by predicting the reactions to an innovation and how those reactions may compel a certain outcome.

Relative advantage, in the context of telehealth, observes if the innovation creates health benefits over and above the current healthcare delivery method. Compatibility considers if the environment is ready for a technological innovation. Complexity observes whether telehealth is more difficult to adopt than traditional healthcare delivery methods, and observability considers whether the results of the innovation are visible to others. Among these characteristics, and for this sample population, the benefits that telehealth brings to existing healthcare delivery and the ability for the environment to accommodate the innovation, are the key considerations. Whether or not the innovation is complex or observable, are less influential in the model. This observation contributes to the literature because it highlights that the different characteristics of DoI theory do not all apply equally to predicting telehealth adoption, in particular the forms of telehealth considered to be innovative.

Conclusions

This research inquired as to what factors drove telehealth adoption. A total of 84 states were included in the sample to determine the extent (if any) to which variables of relative advantage, compatibility, complexity, and observability affect telehealth adoption success measures of teleradiology, teledermatology, telepathology, telepsychology, and remote monitoring. Ordinal logistic regression analyses were conducted to test the hypotheses posed in the study and the results help substantiate the influence of some factors put forth in the literature more than others, as well as support the greater influence of DoI characteristics over others. Overall, the null can be rejected for relative advantage and compatibility, such that the series of ordinal logistic regression analyses determined strongest support for the parameters measuring relative advantage and compatibility DoI characteristics. The individual parameters that are significant within the relative advantage characteristic include communicable disease, non-communicable disease, and life expectancy, all predictive of remote monitoring. The individual parameters significant in the compatibility characteristic include rural population, as predictive of teledermatology, and ICT Index, as predictive of both telepathology and remote monitoring.

Malawi is an instructive example of how the findings come together. Malawi has an established teleradiology program, but no others. In the regression for remote monitoring, life expectancy, communicable disease, non-communicable disease and ICT index are significant. Malawi has higher communicable disease, but lower life expectancy, non-communicable disease, and a lower ICT index score suggesting, therefore, that Malawi might not be well-positioned for successful remote monitoring adoption. This is consistent with what the existing relevant literature would suggest about these relationships. For example, having high communicable disease and low life expectancy implies the medical needs are likely more acute, making it appropriate that the only form of telehealth that was measured in this study and successfully adopted by Malawi is teleradiology—a method for medical imaging and diagnosis. Malawi has lower non-communicable disease, the types of disease that lend better to 'monitoring.' In addition, Malawi's ICT index score is low suggesting the technological infrastructure is not fortified to an extent that would support remote delivery of care, nor that the relative advantage of remote monitoring is perceived as valuable over and above the traditional methods of delivery.

In this chapter, analyses were presented to summarize the implications of the results for each of the models pertaining to the research question, followed by an analysis of how these findings related back to the literature and theory. Key findings were next reviewed and highlighted the contributions these findings make to the literature. The next chapter, Chapter VI: Conclusions, will review the validity of hypotheses, limitations of the research, and recommendations for research and policy.

CHAPTER VI – CONCLUSIONS

Telehealth has been demonstrated to facilitate positive outcomes for the health of populations and address access gaps in the delivery of care (Wootton et al., 2009). With all its benefits, telehealth has seen more success in some state systems than others and understanding the conditions for that success adds to the existing research in a substantive way. This research sought to identify conditions that compel the success of telehealth adoption at the systems level. In addition to applying DoI theory to organize the literature's key indicators of success, the application of the quantitative method helps create a starting point for measurement of those indicators and illuminate their predictability. Parameters identified for this study resulted from a survey of the literature and research indicating the direction and influence of key factors in telehealth adoption. This research found partial support for the hypotheses, which helps to further explain the conditions under which telehealth is successful at the systems-level.

Overall, the best-fitting model was found for remote monitoring. In addition, the strongest support was found for the relative advantage and compatibility characteristics of DoI, though the observability characteristic approached significance for teleradiology and telepsychology. Complexity was not a significant predictor of any of the dependent variables of successful adoption. However, for teleradiology, telepsychology and remote monitoring, the overall models were significant suggesting combined value of all independent variables entered. The individual parameters significant within the relative advantage characteristic include communicable disease, non-communicable disease, and life expectancy, all predictive of remote monitoring. The individual parameters significant in the compatibility characteristic include rural population, as predictive of teledermatology, and ICT Index, as predictive of both telepathology and remote monitoring. As these characteristics were applied to the analysis, more parameters proved individually significant when predictive of remote monitoring. The following sections discuss the validity of the hypotheses put forth for this research.

Review of Hypotheses

H1: Relative Advantage Affects Successful Telehealth Adoption

All parameters measuring relative advantage are either significant (p-value <.05) or approaching significance (p-value <.10) for at least one of the dependent variables, providing support for this hypothesis. Child mortality, life expectancy, healthcare expenditures per capita, communicable disease prevalence, non-communicable disease prevalence, and population age 65+, were all indicators representing conditions under which a new method of healthcare delivery is preferred over a traditional method. This suggests that for states high in all significant relative advantage parameters, the likelihood of successful telehealth adoption is increased. For example, Panama has high child mortality, life expectancy, healthcare expenditures per capita, communicable and non-communicable disease, and lower average population over age 65, yet Panama only has an established Teleradiology program, no others. From the standpoint of relative advantage, it may be worthwhile to further assess Panama's readiness and benefits of adopting additional forms of telehealth, remote monitoring in particular. Relative advantage has a significant relationship with remote monitoring and approaches significance for teledermatology, telepathology, and telepsychology. It is not a significant predictor of teleradiology. Indicators approaching significance are also reviewed because this is an exploratory model and is intended to better understand factors influencing the outcomes. These findings are equally important to better quantify and identify direction of influence in future research.

Teleradiology. As teleradiology is the most widely used form of telehealth represented by the data, it is an important finding that no predictors are significant. Teleradiology was found to have a higher trialability index that made experimentation during the early stages possible which could be at least partly responsible for its early adoption (Helitzer et al., 2003). A key finding in this research is that teleradiology is more matured and accepted than the younger forms of telehealth, with 62% of established programs. The overall model for teleradiology is, however, significant (p-value <.05). Therefore, while enough error has been reduced by the model variables, the current literature may benefit from more localized measures of telehealth adoption, or additional interaction terms, to better predict adoption of this more established method of telehealth.

Teledermatology. There is no significant relationship between relative advantage indicators and teledermatology, though two indicators approaching significance included healthcare expenditures per capita and population ages 65+ (p-value < .10). Teledermatology is the second most broadly established application of telehealth, using both store-and-forward and real-time visits. As it pertains to relative advantage, these results align with previous research on teledermatology that main influential factors are solving for commuting challenges or loss of productivity (Bergmo & Johannessen, 2006; Grady, 2014; Wootton, Bahaadinbeigy, and Hailey, 2011). This suggests that as healthcare expenditures and population age 65+, increase, there may be a relationship to explore regarding access challenges and successful adoption of teledermatology telehealth programs.

Telepathology. There is no significant relationship between relative advantage and telepathology. As stated in the literature reviews, for successful telehealth adoption under DoI framework, relative advantage would need to be high for successful adoption to occur (Civita & Dasgupta, 2007), however, this was not found with telepathology in this study. Child mortality, life expectancy, communicable disease, non-communicable disease, and population ages 65+ are not predictive of telepathology adoption. This implies that the relative advantage of telehealth, in the case of telepathology, does not drive adoption. However, healthcare expenditures per capita approaches significance (p-value $< .10$). This suggests that as healthcare expenditures rise, so too does the opportunity for telepathology adoption.

Telepsychology. For telepsychology, communicable and non-communicable disease prevalence approach significance (p-value $< .10$). While not statistically significant (p-value $< .05$), this relationship suggests that the greater the prevalence of disease, the more likely the adoption of telepsychology. This is consistent with the literature, in that the prevalence of disease indicates an increased health burden to societies (NIC, 2002; Rutherford, Mulholland & Hill, 2010) and the relative advantage of adopting telepsychology may increase on this basis.

Remote Monitoring. The indicators most strongly related to the success of the remote monitoring outcome include life expectancy (p-value $= .049$), communicable disease (p-value $= .03$), and non-communicable disease (p-value $= .027$). Child mortality is approaching significance (p-value$<.10$). This suggests that as measured by the predictor variables, relative advantage, or the perceived benefit of telehealth over a traditional method of healthcare delivery, is strongest in predicting successful remote monitoring. Literature has identified a positive relationship between telehealth adoption and the age of populations (i.e., life expectancy), and prevalence of disease (i.e., communicable and non-communicable) (Hillman & Schwartz, 1985). These variables convey the notion that the relative advantage of taking on a new innovation is more compelling than the traditional method of delivery because the burdens of an aging population and increasing prevalence of disease are pressure enough to be indicators of what would influence greater remote monitoring in a state.

It is a key finding of this research that remote monitoring has the highest number of pilot programs (34.5%), nearly double the remaining forms of telehealth. This highlights what is different about remote monitoring compared with teleradiology, teledermatology, telepathology, and telepsychology: the former is a new innovation, recently becoming broadly available, whereas the latter forms of telehealth are more established and have been employed broadly over the years (Bashur and Lovett, 1977). Therefore, this research points out the application of the DoI framework may be best applied as a new innovation is launching as a predictor of success, rather than applied as a retrospective for programs that are more established or mature.

H_2: Compatibility Affects Successful Telehealth Adoption

Overall, two parameters measuring compatibility are either significant (*p*-value <.05) or approaching significance (*p*-value <.10) for at least one of the dependent variables, providing support for this hypothesis. Compatibility measures included rural population, out of pocket expenses and the ICT index and were measures for a construct on whether telehealth met with the needs and values of the populations being served. Literature has shown that insufficient ICT systems (Steele & Lo, 2013)—both availability and technological complexity—together with attitudes of the rural populations in leveraging technology (Gagnon et al., 2006; Moloczij et al., 2015) pose barriers to adoption of telehealth. Rural health, for example, is the most apparent application for telehealth, as it solves for physical access gaps (Burch, 2017; Piette et al., 2012). Out of pocket expenses are an indicator of differing costs held by the consumers of healthcare in the different state populations and the cost barriers to accessing care (de la Torre et al., 2003). The ICT index measured the extent to which technology was enabled in different states and whether telehealth was even viable given that infrastructure, or whether telehealth was compatible with the conditions that may compel or impede successful adoption. Of these, ICT index was a significant predictor of telepathology and remote monitoring (p-value<.05) and approached significance for telepsychology. Rural population was a significant predictor of teledermatology and approached significance for remote monitoring. An example of a state for whom further telehealth maturation could be viable, is Croatia. With both higher than the sample average for ICT index and size of the rural population, Croatia has only an established teleradiology, but is piloting the remaining four types of telehealth.

Teleradiology. No compatibility parameters were significant or approaching significance for teleradiology. This implies that technology infrastructure, having a large rural population and out of pocket expenses are not considerations in the adoption of teleradiology. This is an important finding, as teleradiology can be widely used in different formats using non-innovative technologies and communication methods. Whether or not, for example, ICT infrastructure is matured, teleradiology can still occur, which is suggestive of its cost-effective practical applicability as found by Zundel (1996).

Teledermatology. Rural population, in this model, is a significant predictor of teledermatology adoption (p-value<.05). This is consistent with what would be expected given that dermatology is a specialty in healthcare and rural populations more commonly commute to urban centers to attain access to specialty care (Ouma & Herselman, 2009). This finding suggests that a driver of teledermatology adoption is the compatibility it provides for rural populations. This model also conveys that ICT Index and out of pocket expenses on healthcare are not predictive of teledermatology adoption. This is helpful to note, because the presence of physical access barriers (i.e., rural) drives teledermatology but the need for ICT infrastructure and low out of pocket expenses does not contribute. Therefore, populations are more likely to invest in teledermatology if it solves their access issues, despite other considerations.

Telepathology. The ICT Index is a significant predictor (p-value<.05) of telepathology. This is inconsistent with what is described in the literature, as pathology is a specialty field focused on the diagnosis of disease from laboratory analysis. Similar to teleradiology, telepathology can leverage more advanced innovations in technology, such as the internet, but may also rely on traditional methods of sharing information, such as mail, fax, or phone. What this implies, and since gross national income per capita (GNI) is held constant in these models, is that there may be other reasons for why ICT compels telepathology adoption. One reason is that telepathology has more and more broad applications as the global health burden rises, and therefore pathologists require additional technology to service a growing demand. As such, insufficient ICT systems may constitute a technological barrier to adoption (Van Dyk, 2014). This finding may benefit from additional research and cost/benefit studies. Out of pocket expenses are not predictive of telepathology adoption.

Telepsychology. Compatibility, overall, is not a significant predictor of the successful adoption of telepsychology. ICT Index does approach significance as a predictor of telepsychology (p-value<.10), however. This finding is consistent with the literature (Moore, 2009) in that psychology is a real time encounter and does not rely on store-and-forward methods of communication. Telepsychology therefore relies on more sophisticated technology to support its adoption, and this finding would be a helpful consideration for any institution seeking to adopt telepsychology because it suggests that infrastructure is important. Out of pocket expenses are not predictive of telepsychology adoption.

Remote Monitoring. ICT Index is a significant predictor of remote monitoring (p-value<.05), and rural population approaches significance (p-value<.10), while out of pocket expenses are not predictive of remote monitoring adoption. This finding is consistent with what would be expected, in that ICT and technological infrastructure is needed to support remote monitoring. In addition, remote monitoring is compatible with the condition of a higher rural population and helps to address the access challenge (Penchansky and Thomas, 1981).

H3: Complexity Affects Successful Telehealth Adoption

There is no support found for the hypothesis that complexity, as measured by the number of physicians, affects successful adoption of teleradiology, teledermatology, telepathology, telepsychology, or remote monitoring. This is an important finding given the focus in the literature on the need for skilled resources (Penchansky & Thomas, 1981;

Peters et al., 2008; Ranson et al., 2003; Wootton, 2009), when these findings observe the opposite. In effect, this finding suggests that the quantity of physicians is not a requirement of successful telehealth adoption, but the influencer may be increased access to the already existing physicians. This is a beneficial finding because it reinforces the benefits of telehealth—increasing access without necessarily increasing resources.

H_4: Observability Affects Successful Telehealth Adoption

There is no support found for the hypothesis that observability is predictive of successful telehealth adoption. The Human Development Index (HDI) approached significance for teledermatology and telepsychology (p-value<.10), while perceptions of health quality was not significant for teleradiology, teledermatology, telepathology, telepsychology, or remote monitoring. The HDI incorporates several components of human development to include: life expectancy, which represents longevity of life, mean years of schooling, representing the ability to acquire knowledge, and gross national income, to represent achievement of a certain standard of living (UNDP, 2016). This may be worthwhile to study further to better understand if increased human development has implications for whether telehealth will be successfully adopted. For example, Ireland and Iceland have no teledermatology or telepsychology programs, yet have among the highest HDI scores. There may be some benefit to exploring these types of telehealth for these states.

Teleradiology. No observability parameters were significant or approaching significance for teleradiology. This implies that HDI and perceptions of health quality are not considerations in the adoption of teleradiology. This finding clarifies the relationship between observability parameters and the impact on teleradiology adoption.

Teledermatology. The HDI approaches significance for teledermatology (*p*-value<.10), suggesting a positive relationship between human development and this type of telehealth. Dermatology, while a vast global health challenge, is a specialty offering that may compel a certain standard of human development (i.e., education) to expand or have demand for this offering.

Telepathology. No observability parameters were significant or approaching significance for telepathology. This implies that HDI and perceptions of health quality are not considerations in the adoption of telepathology.

Telepsychology. The HDI approaches significance for telepsychology (*p*-value<.10). Similar to teledermatology, while mental health is a strong global health need, telepsychology is a specialty offering that implies a need for a certain level of HDI. This may be of interest to explore further how perceptions of specialty care align with human development and therefore investment in closing healthcare gaps.

Remote Monitoring. No observability parameters were significant or approaching significance for telepathology. This implies that HDI and perceptions of health quality are not considerations in the adoption of remote monitoring.

Limitations of Research

Limitations of this research are associated primarily with the data employed in the study. First, as an exploratory study and the focus being on advancing the quantitative contributions to the literature, the use of published state-level data limited the number of factors that could be explored to represent the DoI characteristics. Further, of the state-level data available that coincided with what the literature says about influencing variables, were limiting to more direct measures of telehealth. For example, having direct measures of attitudes toward telehealth for all states was prohibitive. As a result, there may be some challenges to external validity introduced by the lack of availability of more direct measures of adoption.

In addition, the DoI theory includes social system, time, communication, and the trialability characteristic of the innovation component that were not included in this model. DoI recognizes that there are many social factors that contribute to adoption of innovation, but this study chose to focus the most applicable attributes of the theory to maintain scope to the research question. Therefore, the full DoI theory was not applied to this analysis.

Recommendations

Recommendations for Policy

It is worth noting that the variables expressed as influencing telehealth adoption mostly held true for remote monitoring, the youngest of the disciplines. This suggests it is a viable hypothesis and that the factors observed in the literature are important in early consideration of adoption, but once greater saturation occurs (i.e., for teleradiology that has the highest successful adoption and is the older of the disciplines), other variables matter. It is worth considering if, after a certain level of saturation, there isn't a leveling off of adoption, or a plateau that may only gradually evolve into further adoption, using a different theory than DoI. Future research may benefit from looking at the adoption rate across states and if, in diffusion, there are stalling periods after a certain point, after which other factors come into play to affect continued diffusion.

This research is foundationally beneficial when considering policy because it clarifies that all forms of telehealth, and their ultimate success within the context of each state, are not equivalent. Having applied the same model representing DoI characteristics to each of the types of telehealth (teleradiology, telepathology, teledermatology, telepsychology, and remote monitoring), predictability of diffusion was strong only for remote monitoring. This suggests that the application of the technology (i.e., store and forward vs. real-time) is also a consideration that is not clearly and consistently recognized in the literature. What this finding adds to the discourse, and to policy, is that innovating, such as through remote monitoring, creates conditions under which the predictors of successful telehealth adoption become relevant.

Lack of innovation, such as with the widely adopted teleradiology, meets with a different set of predictors. This is important because policy-makers and institutional influencers can benefit from knowing what conditions are optimal for making large institutional investments and changes to the way healthcare is delivered. The simple finding that the conditions touted in the literature as being predictive of success hold in the context of ‘innovation,’ rather than accepted technology, can prepare states for future innovations in healthcare. For example, stroke is known as a leading cause of death in the United States (U.S.). Patients treated more rapidly have lower likelihood of brain damage or death, though individuals living in rural areas may be challenged to get acute care timely, thereby increasing risk and cost for this population. Telestroke is a type of telehealth that enables emergency services (i.e., ambulances) to administer faster responses by communicating synchronously in real time at the side of the patient with the hospital for more immediate diagnosis and treatment. This is a more advanced type of technology than teleradiology, for example, because there are more moving parts to organize such as equipment that needs to work remotely or increased workforce training.

This is an innovation in telehealth that is less widely adopted, newly being explored, and may lend itself to the model discussed herein.

As stated, the best model fit applied to remote monitoring. This suggests that states who have the characteristics of successful adoption, but have not yet implemented a program, may leverage this finding to reinforce its addition to strengthening the healthcare system. On the other hand, states not displaying predictive characteristics, such as high life expectancy and a high ICT index, may consider if there are other healthcare system investments that may be made to help bolster the existing infrastructure and achieve greater healthcare outcomes without over-reaching for innovative tools.

Recommendations for Practice

States that consider expanding their telehealth disciplines should take note of and further explore variables that have implications for sustained adoption. One such variable, whether ICT is robustly in place, has staying power despite the maturity of the telehealth application. This therefore further suggests there are additional factors not widely explored in telehealth regarding continued adoption, or that a non-innovation model is more important once a certain level of telehealth maturity is achieved. Further research in the implementation of high ICT-dependent telehealth disciplines such as telepathology, telepsychology and remote monitoring where there is a large rural population might yield insights towards a different offering which would increase adoption.

Another finding to consider in practice, is that adoption of specialty care delivery including teledermatology and telepathology, are primarily driven by having a larger rural population and a high ICT index, respectively. For both specialties, healthcare expenditures per capita approaches significance. This suggests that, a state considering adoption of teledermatology, is more likely to be successful in areas with a larger rural population because of the compatibility of this type of delivery with meeting the population healthcare needs. With the proportionately lower number of specialists, dermatologists specifically, and the observation that most specialists are located in urban centers, this would be an area states could assess if the value to closing the geographical access gaps to solve dermatological challenges adds value to their healthcare systems. Similarly, states with a strong ICT index may be better poised to offer telepathology services, which also closes an access gap to care.

Conclusions

In a first attempt at generalizing indications of successful telehealth adoption at the state level, this research has promising implications for future research, having quantitatively explored the relationship between the Diffusion of Innovation theory, factors put forth in the literature as influencing telehealth adoption, and the system-level adoption of telehealth itself. It has been reviewed that telehealth has faced barriers to adoption and this research sought to further explore whether there was a predictive model of adoption success that could be applied and considered for state adoption. The DoI theory proved beneficial in organizing the factors explored in the literature as being influential to the research question and helped to illuminate that there are different influencers involved for mature telehealth programs when compared to burgeoning telehealth programs. That is, telehealth in general, is not an innovation despite its relative youth to traditional healthcare delivery methods. Remote monitoring, however is a newer form of telehealth, that finds partial support of DoI theory.

Remote monitoring was added as a new type of telehealth measured by WHO in 2015. This is as a result of its new expanding application. With over one-third of programs in remote monitoring in their pilot stage, compared to a 77% established program rate of teleradiology, it was valuable to observe how the research models acted so differently depending upon program maturity. The best fitting model was observed for remote monitoring suggesting that DoI theory is best applied to the prediction of telehealth adoption specific to new methods of telehealth delivery. In effect, this model will be beneficial to apply in observation of new types of telehealth as they emerge, with a particular lean toward observations of relative advantage and compatibility measures.

Of practical importance is the finding that relative advantage compels successful adoption is important for the consideration of additional diffusions. Opinion leaders and institutions may benefit from focusing efforts on increasing the perception of value of telehealth with the aim of increasing the successful and sustainable adoption. For relative advantage to have this relationship to remote monitoring adoption suggests that the benefits provided by this delivery method are broadly perceived to have an impact over and above the traditional method of delivery.

In addition, compatibility, or whether a new technology can be easily accommodated into the context of its application, is an important factor for practice. For states to consider investments into new applications of telehealth, understanding the landscape of relative advantage and compatibility could prove beneficial. For example, mobile health (mHealth) is becoming more broadly used to facilitate mobile self-care with the use of mobile devices, such as cellular phones, that may serve to foster better preventive care in an early attempt to keep populations healthy. This new type of telehealth, or others like it, may benefit from the same considerations under study in this research.

Further, the different types of telehealth, whether synchronous or asynchronous matter. The store-and-forward, or asynchronous, telehealth delivery including teleradiology and teledermatology did not have any strong relationship with ICT Index, which is often touted in the literature as a key predictor (Wooten et al., 2009) of adoption. The relationship to ICT is true for telepathology, telepsychology, and remote monitoring, however, likely because they are real-time, synchronous, visits and require more mature technology to support the delivery of care. This is a beneficial secondary finding because it highlights that not only does maturity of a program matter to this model, but so too does the method of delivery used for the specific telehealth application.

In sum, this research set out to observe the systems-level conditions that influence telehealth adoption and, through both identifying a best-fitting model and clarifying context for the impact of those influences, the findings contribute to better understanding of this discourse and can help pave the way for future research. Recalling the "triple aim," or the goal of enhancing the patient experience, reducing cost, and improving population health (Berwick, 2008), this advancement of the research will be helpful in honing the tactics employed and where time and resources can or should be spent to achieve the greatest outcomes for populations. While many telehealth programs are started and stopped or do not maintain their longevity, it would be first worthwhile to understand better current state conditions and whether they lend well to successful innovative telehealth adoption.

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