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A Multi-Level Assessment of Healthcare Facilities Readiness, Willingness, and Ability to Adopt and Sustain Telehealth Services

Jamie Larson
University of Nebraska Medical Center

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By

Jamie Larson

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Supervisory Committee

Li-Wu Chen, PhD

Dejun Su, PhD

Jungyoon Kim, PhD

Ronald Shope, PhD

Abstract

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Jamie Larson, Ph.D.

University of Nebraska Medical Center, 2018

Supervisor: Fernando A. Wilson, Ph.D

Telehealth technologies are becoming more pervasive throughout the healthcare system as a way to provide services to patients that would otherwise have difficulty with access. Currently, little is known about the current state of telehealth use within clinics and hospital in the US. Most studies evaluating telehealth programs are feasibility or small patient outcome studies from one location. Utilizing a hybrid framework combining the levels of complex socio-technical systems with the theory of ready, willing and able. The theory of ready, willing, and able is founded on the basis that these three preconditions need to be met for a change in behavior to occur, such as adoption of telehealth technologies.

Study 1 utilizes multiple national healthcare data sets to analyze the higher levels of organizational factors that are associated with US hospitals who are ready and willing to implement telehealth technologies but lack the ability. Providing insight to the factors that can facilitate the ability to adopt such innovations. Study 2 is a mixed methods study that evaluates clinic data from the state of Nebraska. The quantitative survey data was used to develop interview questions and determine the sample population. The qualitative interviews yielded several themes on barriers to implementing and sustaining telehealth

services in Nebraska. These include lack of providers to network with and technology malfunction issues. Many clinics want to increase their telehealth programs but are lacking the ability to do so. Study 3 is a combination of two meta-analyses that evaluate the effect of telehealth programs on the QOL for cancer patients in treatment and cancer survivors who are no longer in active treatment. The effect of the telehealth interventions on survivors QOL is significantly increased compared to survivors in usual care.

More needs to be done to standardize telehealth evaluation and connection processes. Positive patient outcomes and clinical benefits can strengthen the legitimacy of telehealth technologies as part of normal healthcare practice. Yet without accurate data, the benefits cannot be fully assessed. Innovation is outpacing policy and procedures, this needs to be amended to fully maximize the benefits of telehealth technologies in the healthcare system.

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List of Abbreviations

ADI	Area Deprivation Index
AHA	American Hospital Association
APRN	Advanced Practice Registered Nurse
ARRA	American Recovery and Reinvestment Act
BREATH	Breast Cancer E-Health
CI	Confidence Interval
CINAHL	Cumulative Index for Nursing and Allied Health Literature
CMS	Centers for Medicare & Medicaid Services
CPT	Current Procedural Terminology
CS	Complex System
CSTS	Complex Socio-Technical System
DHHS	Department of Health and Human Services
ED	Emergency Departments
EHR	Electronic Health Record
EORTC QLQ-C30	European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 items
FACT	Functional Assessment of Cancer Therapy

FSHR	Fully implemented in all units, Implemented in one unit, partially implemented in one unit, and have resources to start implementing next year
HHI	Herfindahl-Hirschman Index
HIE	Health Information Exchange
HIPPA	Health Insurance Portability and Accountability Act of 1996
HIT	Health Information Technology
HITECH	Health Information Technology for Economic and Clinical Health
HPSA	Health Professional Shortage Areas
HSA	Hospital Service Areas
HPTS	Health Professions Tracking Services
HRSA	Health Resources and Services Administration
IBM	International Business Machines Corporation
IT	Information Technology
MD	Medical Doctor
NA	Not Applicable
NE	New England
NPNC	Not in Place and Not Considering Implementation
NRCI	No Resources but Considering Implementation
PA	Physician Assistant

PCMH	Patient Centered Medical Home
PEDro	Physiotherapy Evidence
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QOL	Quality of Life
RCT	Randomized Controlled Trial
RPM	Remote Patient Monitoring
RWA	Ready, Willing, and Able
S&F	Store and Forward
SDS	Symptom Distress Scale
SPSS	Statistical Package for the Social Sciences
Std	Standard
UC	Usual Care
US	United States of America

Chapter 1: Introduction

I. Background

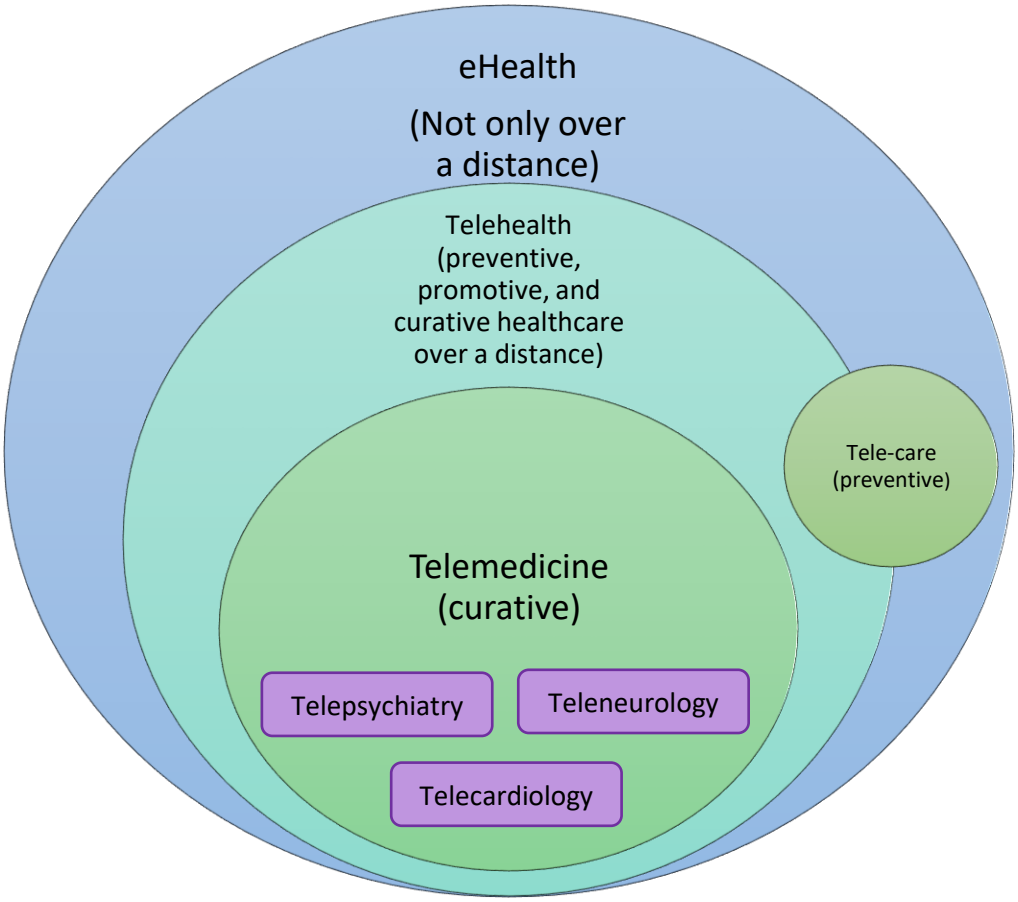
Communication technologies have been of interest in the delivery of healthcare services worldwide for several decades. These communication technologies, better known as telehealth technologies, have the potential to address several healthcare delivery issues, including the limited access to healthcare services of populations, such as those in rural areas or persons who are disabled, alleviating the uneven quality of care with currently available healthcare services, and addressing aspects of the rapidly rising cost of healthcare.[1–12] Telehealth services can decrease travel and time costs for both rural patients and providers, especially those with chronic conditions that need regular follow-up and monitoring.[13,14] Telehealth technologies have the potential to expand the availability of healthcare resources, especially in shortage areas, providing greater access to underserved areas.[12,15] Additionally, they are used to make continuing medical education possible for rural healthcare providers, potentially improving rural healthcare organizations retainment of healthcare providers.[3,12] As the population over 65 years of age continues to grow exponentially the need for chronic care management that is efficient and cost-effective will rise.[15,16]

The terms ‘telehealth’ or ‘telemedicine’ are often used interchangeably and can have multiple definitions. Telemedicine is usually used to refer to diagnosis and monitoring technology used between patient and provider, whereas telehealth may also include management, education, and other allied health care services.[17] The Health Resources and Services Administration defines telehealth as the use of technology to

deliver health care, health information, or health education at a distance.[18] Telehealth technologies, including telephone, videoconferencing, and internet-based interventions, have the capability of bringing services into the patient's home and assisting them in the management of their symptoms without the need to be physically present at a hospital or clinic.[19,20]

Figure 1.1 displays additional terms which have been used, including eHealth and Tele-care. eHealth has been described as including all the other sectors of telehealth but does not need to be over a distance.[4] Tele-care is under the umbrella of prevention, so it is not grouped under telemedicine but is a part of telehealth and eHealth. [4]

Figure 1.1: Definitions of the Forms of Healthcare Communication Technology



There have been many studies on the feasibility of telehealth technology in almost every type of healthcare service sector.[20–29] Feasibility studies have shown evidence that telehealth technology used to deliver services is as effective as in-person medical care for many health problems. [1,30–32] Case studies and reviews have assessed the effect this technology has on access, quality, and cost of care.[1,6,33–35] Satisfaction and acceptance of telehealth services by both providers and patients have also been widely studied in many healthcare settings, with most studies showing high satisfaction and acceptance rates.[1,14,36–38] Studies on comfort with the telehealth technology have noted people who are younger, have more education, and live in rural or remote regions are more likely to feel comfortable with using telehealth services.[30,39]

Within chronic care management, new business models are emerging in relation to changes in public and private policies that are designed to improve outcomes and reduce spending, which includes the adoption of enabling technologies such as remote patient monitoring (RPM).[40] Telehealth technologies are a useful tool for healthcare providers in the early detection and rapid intervention of disease or complications, particularly through the use of monitoring technology.[41–43] Personal biomedical devices and wearable sensors can be used to monitor the status of the patient while at the same time increasing their adherence to treatment.[39,44]

Early adopters of RPM technologies have identified six key elements that were improved in the management of chronic disease care: 1.) early intervention, through monitoring and early detection; 2.) integration of care, as digital data is more easily exchanged; 3.) coaching, enhanced ability to encourage behavioral change and self-management; 4.) increased trust, patients feel more connected with provider; 5.)

workforce changes, can utilize more plentiful and lower cost health care workers; 6.) increased productivity, decreased travel time for patients and automated documentation. [40,45,46]

II. Barriers and Challenges

Despite the many studies within multiple areas of healthcare on the effects of telehealth technology there has yet to be a consensus on the issues of sustainability of telehealth services and the precise effect and role it has in mainstream healthcare.[1,47,48] There has been no determination on whether telehealth technologies will fill a unique niche in healthcare to expand access to those who lack access due to geography, isolation, or other barriers, or if it will be integrated as a necessary and normal component of all healthcare.[1] In the case of full integration, telehealth will become an essential component to enhance healthcare efficiency, quality equity, and cost containment.[1,48,49] The benefits of telehealth technology that have been seen in smaller scale program studies are unlikely to materialize without integration into clinical practice.[1,7] As legislative health policy focuses more on health outcome priorities including reducing disparities in access, engaging patients and caregivers in personal health development, improving coordination of care, and improving public health, telehealth will play a key role.[11] To achieve the goal of care coordination and improvement of disparate health outcomes, patients need to receive correct care at the proper site by an appropriate provider while avoiding inefficiencies related to duplication and waste. [11] Telehealth technologies have the capability to address the gaps within this simple equation, particularly when the proper site or provider is not as easily available for patients to access.

One major issue with telehealth use in US healthcare is the question of appropriate and equitable compensation for providers who deliver care to patients via telehealth technologies.[1] Along with compensation, are questions related to who should be allowed to provide telehealth services and therefore eligible for reimbursement? Should telehealth services be restricted to certain diagnostic or clinical services that don't require personal contact for diagnosis or treatment? What is the appropriate and optimal application for these technologies?[1] These types of questions require a better understanding of the technological, organizational, financial, and human resource configurations for the adoption of optimal telehealth technologies.[1]

Local competition among hospitals can influence the organization's decision to adopt telehealth technologies. The race to be the first to have the new innovation in a heavily competitive market can lead to overinvestment in telehealth technology as a way to gain a competitive edge.[50] However, it isn't a matter of adopting for the sake of being the first, but of optimizing the technology for the organization and its patient population, without a particular 'why' for adoption, there can be a loss of advantage rather than a gain. The polar opposite can occur in a healthcare market as well, with competing hospitals forming a gridlock, not wanting to be the first to take the financial risk.[50] The organizations will wait until a physician or patient group asks for the services, or until another organization makes the leap for innovation.[50] There is a need for the legitimization of the technology and a way to understand the benefits before organizations and providers can decide on the adoption of a technology.

Healthcare organizations are struggling to evaluate the increasingly complex and challenging forms of telehealth technologies and functions in providing services.[40,50]

Disruptive technologies change the existing business model and/or work processes. It can be difficult to estimate the impact these technologies will have on clinical programs, operating costs, and the amount of necessary resources.[6,50] New technologies, such as telehealth technology, can add to the uncertainty of capital planning, as there is more uncertainty regarding operating impact, reimbursement, and return on investment. [5,11,50] Although most RPM products have some interface for connecting to EHRs, there is the additional burden of installation and maintenance on systems information technology staff.[40] There are also few models on how to go about implementing these technologies by individual physicians, large medical groups or healthcare delivery systems.[40] Similarly, implementation plans that are available may not be relevant to the type of technology or services that the organization plans to adopt given the many forms of technology available and the multitude of clinical specialties and practice styles. With no uniform quality standards or protocols currently in place, it is difficult for organizations to develop a framework to adopt telehealth services.[11]

Remote patient monitoring is a prime example of disruptive technology, it requires the reworking of the care processes including physiologic monitoring, protocol-driven decision support, new roles for clinical and nonclinical providers and telehealth technology that allow patients to communicate more frequently and at a distance from their providers.[40] Physiological measures will no longer require the patient to come in to be evaluated. New indicators can inform providers to reach out to patients to allow for early intervention, instead of dealing with a post-event occurrence. This change will be substantial in the work process of traditional patient-provider interactions. On the other hand, this disruptive technology can also be a transformative technology, as it allows a

wide range of positive changes in clinical care and administration.[40] RPM can also reduce net expenditures while improving the value and quality of health care. [40]

Patient portals offer patients online access to their personal health records, and can also include access to health educational tools to help manage chronic conditions. [44] Patient portals can allow access to secure messaging to patients' providers creating better communication between patient and provider. The trend of increased contact has continued with emerging smartphone and tablet applications that allow patients to directly download healthcare educational resources, set up appointments, and handle prescription refills. [44]

Policy changes by the Centers for Medicare & Medicaid Services (CMS) and state legislation regarding private insurance mandates related to reimbursement of telehealth services, largely determines the revenue potential that hospitals and healthcare organizations can expect to receive after the adoption of telehealth services.[50] Changes in reimbursement related to quality drivers such as managing chronic care can be a motivator for telehealth technology adoption,.[40] CMS is implementing rewards, particularly through Medicare, for shifting care out of hospitals and emergency departments (EDs), reducing variation in quality of care, and compliance with evidence-based medicine. [40] However, Medicaid reimbursement for these services is varied both in who can provide the services, where the services can be accessed, and for the types of conditions that can utilize telehealth services. [51]

Policy issues occur at many levels within the complex system of healthcare; organizational, state, and national level policies influence the use of telehealth within healthcare facilities. These policies can relate to privacy, confidentiality, security,

reimbursement, and licensure.[13,52] The US Government has invested in advancing the use of telehealth through expanding public awareness, helping to integrate IT, and measuring clinical efficacy. Organizations such as the US Department of Agriculture, the US Department of Health and Human Services (DHHS), the National Aeronautics and Space Administration, the US Army's Telemedicine and Advanced Technology Research Center and the Veterans Administration, have been involved in the development and support of telehealth programs and services. Within the DHHS, CMS is an important player and has the authority to evaluate and determine how the US government may reimburse for the use of telehealth within the Medicare statute.[53] Medicare is the largest single payer in the US and has stated that provision of home healthcare through telehealth is less expensive and more efficient than in-person physician visits. Stating that a physician can make approximately five in-person home visits per day, compared to services provided via telehealth technologies which can allow a provider to contact many more patients in a day with less time spent on travel.[12]

Despite the apparent backing by Medicare, state-level Medicaid policies are still inconsistent, and this leads to confusion of providers and a lack of reimbursement for telehealth services.[9] There has been recent expansions by many states to reimburse for telehealth services, but at the same time many states have added restrictions and placed limitations on telehealth delivered services. Trends in the differing Medicaid state policies suggest that live video reimbursement continues to be the major reimbursable technology covered under Medicaid. Telehealth services utilizing store and forward and remote patient monitoring technology are covered less frequently under the different state telehealth reimbursement policies.[17]

Currently, 48 states and the District of Columbia have Medicaid fee-for-service reimbursement for some form of live video telehealth. Thirteen states have Medicaid reimbursement for store and forward services and 22 states reimburse for remote patient monitoring. Only nine states reimburse through Medicaid for all three types of telehealth service.[17] However, some states limit the reimbursement area to designated rural areas or limit the facilities where services can be accessed, often excluding patients' homes. Limits are also set on the specialties that can obtain reimbursement, the Current Procedural Terminology (CPT) codes used for reimbursement, and the types of providers that will be reimbursed for the provision of telehealth services.[11,17,39] Medicare has limitations on the services and providers that can be reimbursed for telehealth services. Occupational therapists, speech-language pathologists, audiologists, and physical therapists are not recognized as eligible for reimbursement.[54] This creates inconsistent and vague legalities surrounding telehealth services and increased liability concerns.[11,15]

Similarly, some states have required private insurance to cover telehealth services that would be covered if provided in-person, these laws are often written in a way that does not guarantee parity.[55] As of 2017, 35 jurisdictions including the District of Columbia had mandates requiring private insurance to reimburse for telehealth services.[17] Again there are limitations in the way the laws are written, so although there is parity in coverage of telehealth and in-person services, there is not parity in the amount of reimbursement.[55] Lack of reimbursement prevents expansion of telehealth and can also lead to the shutdown of programs if costs continue to be greater than reimbursement. This is especially true for those programs started with grant funding but following the end of

funding are unable to code for proper reimbursement or lack the necessary providers or technology to be reimbursed by public insurance.[56]

The largest barriers cited in the adoption of telehealth are physicians, hospital administrators, and healthcare payers.[30,57] Physicians and hospitals may provide services via telehealth technology as an option of care, but if patients do not feel the services meet their standards, they may seek out services elsewhere.[30] This can make hospitals and physicians wary of investing financial resources into a product that patients may reject.[30] On the other hand, telehealth services can be leveraged to achieve recognition as a center of excellence or provide a form of care at underserved sites in a network that may otherwise go elsewhere.[11] Physicians and healthcare providers are the main users of telehealth technology and have a profound influence on its success within the organization. [2,6,7,10,50] Promoting physicians' decision to adopt telehealth technologies can be challenging due to their relatively low computer literacy, the possible alteration of their workflow and routine, and their high professional autonomy.[1,2,6,10] Similarly, a study of telehealth legislation influences found physician interest group association with a policy had a negative impact on the resulting telehealth policy.[39]

III. Sustainability

Sustainability with regard to telehealth services is when the service is no longer a disruptive technology or special program but has been absorbed into routine healthcare delivery. [3,58] The telehealth program or services system becomes sustainable in the long-term when it is able to respond to external pressures and adapt without negatively impacting the function of the system.[59] Sustainability has many indicators that denote when the telehealth program or service has achieved a sufficient level of maturity to be

productive and sustainable.[48,58] These indicators include the number of telehealth systems in use, the continued use of the systems with increasing demand, a commitment from providers and the organization to invest in the systems, an acceptance of telehealth as part of the core budget and a commitment by the organization to support these services like any other core service provided within the organization.[48,58,59]

In the current healthcare environment, it can be hard for organizations to sustain the use of telehealth technologies in any long-term business model, as they are constricted by direct fee-for-service reimbursement, which is often not sufficient to sustain telehealth services.[1,40] Likewise, as reimbursement methods shift away from retrospective fee-for-service this may be perceived by the organization or provider as a less reliable recurring revenue source. Therefore, unless there is demonstrated benefit for patients, providers, and the organization that is seen as greater than the risk of investing in both the infrastructure and resources necessary to operate these services the adoption of the technology will not occur.[1,50] Some organizations, however, are recognizing the financial benefits of downstream revenues created by the use of telehealth and the ability to avoid penalties, such as readmission penalties, that are assessed in the technologies return on investment (ROI).[11]

The American Recovery and Reinvestment Act (ARRA) of 2009 included health information technology (HIT) and telehealth policies, which helped boost adoption, as well as, funding aimed at improving quality, safety, efficiency, and reducing health disparities. [11] The ARRA included $22 billion in subsidies for improving and upgrading HIT. The Health Information Technology for Economic and Clinical Health (HITECH) Act provided an additional $10 billion for health research and construction of facilities. [11]

Care coordination and health systems connectivity are part of the core elements of the healthcare reform, much of which is focused on EHRs, meaningful use, and health information exchange (HIE).[11] Telehealth has been increasingly used to facilitate the Patient-Centered Medical Home (PCMH) model. The Agency for Healthcare Research and Quality has specified telehealth technologies as a HIT application that can facilitate many of the principles of the PCMH model. [11]

Currently, many of the private sector telehealth programs are heavily reliant on non-recurring extramural funding or appropriations from state and/or federal sources.[1,15] These funds have promoted the initial stages of development and in some instances continue sustaining telehealth programs beyond their initial funding period.[1,15] However, these non-recurring grant funds cannot sustain programs in the long-term, and there needs to be a revenue source capable of filling the financial void.[1,60] Similarly, there is a growing number of federal and state agencies that are providing programs and grants to telehealth services as a way to enhance the PCMH concept. [11] Yet in an era of healthcare policy turbulence, the reliance on these grants could be detrimental in the long-term, leaving a hole in the optimal use of implemented technology and future reimbursement for the associated services. Even with recurring funds, such as reimbursement for services, these payments will not cover the infrastructural costs for initial adoption and may not be substantial enough to cover technology maintenance and updating requirements.[31] There needs to be a way to balance the resources within the organization for designing and implementing telehealth technology and continuing with adequate return to cover future technology and program needs.

Joseph and colleagues (2011) conducted a qualitative study on the sustainability of telehealth programs and found that many programs ran for a year or less. [61] Although meant to be long-term programs, they were unable to transition from short-run programs to long-term clinical norms.[61] Some of the programs in this study did run for several years but were discontinued for numerous reasons; including lack of organizational support, insufficient demand, issues with the technology, and lack of funding.[61] Barriers to sustaining the telehealth programs that were noted in the study included staff sometimes seen as technophobic, and clinics were reluctant to participate in a service that has yet to be clinically proven legitimate. Another noted barrier was the insufficient funding for information technology (IT) staff and equipment.[61] Payment rates often do not consider the implementation costs related to telehealth technologies or the costs of coordination and scheduling services among multiple sites. Several studies have found that the field of telehealth practice seems to be mainly built on trial and feasibility studies that never go beyond the specific research and development funding initiatives; with only teleradiology finding a normative foothold in clinical practice.[62–65] Failures occur for many reasons, but the underlying cause is the underestimation of the obstacles that inhibit the transition from a successful pilot to a full program integrated at a larger scale.[4,66] To sustain a telehealth program their needs to be adequate resources for deployment and maintenance, that requires every part of the system to be designed around the financial and operational context of the participating organizations.[4,66]

IV. Previous Studies

The factors that influence institution adoption of telehealth technology are still not well understood. [9,13,47,49] An organizations decision to adopt and invest in telehealth is

determined by many factors, some internal such as organizational structure and some external, such as market and government policies.[9] Rural area hospitals have access to federal funds that are used to improve care accessibility, which may increase the rate of telehealth adoption in rural hospitals compared to more urban areas. [9,18] Rurality has been shown to increase the rate of adoption of telehealth technologies compared to urban organizations.[9] Market competition may cause an organization to adopt telehealth as a way to give themselves a competitive edge.[9]

Alder-Milstein and colleagues (2014) found a statistically significant increase in adoption by hospitals that had greater technological capabilities, those that were part of a larger network, and organizations designated as a teaching or academic hospital.[9] State policies were also found to affect adoption, legislation requiring parity reimbursement by private insurers for telehealth services equal to that of in-person visits had the most significant effect of increasing adoption. However, policies requiring providers to have special licenses for providing telehealth services, particularly for Medicaid patients, made adoption less likely. [9]

A study on the feasibility, acceptability, and sustainability of a telepsychiatry program found issues with sustainability. The program had an overabundance of Medicaid and public payer cases, which meant there was insufficient reimbursement for the services based on the fee-for-service model.[31] The authors conjectured that as a single clinic the program would not be sustainable, but other larger medical centers might be able to handle the reimbursement gap in order to meet the mission and interest of the center's stakeholders.[31] Sciamanna and colleagues (2007) assessed the likelihood of seeing a provider who conducted internet or email consults using ambulatory clinic data.

[67] They found that the likelihood increased when visiting a primary care provider and being in the western region of the US. Patient and physician characteristics also were attributable to an increased likelihood of seeing a provider who utilizes internet or email consultations.[67]

The gap in previous studies revolves around the lack of a national telehealth database that can provide information on telehealth use in the US and the factors that drive and sustain this technology. As previously mentioned, many of the studies are disease or location specific, predominantly pilot studies on the feasibility and acceptance of these programs. There are of course studies on patient outcomes, but there is no universal standard to determine the success of telehealth technology. This dissertation includes three studies that address several research questions. Study one consists of a logistic regression of organizational and environmental factors that affect the adoption of telehealth and RPM. The second study is a mixed methods study of Nebraska telehealth and the challenges and potential sustainability of current telehealth programs. The final study is a combination of two meta-analyses of telehealth interventions effect on the quality of life (QOL) of cancer patients.

V. Research Questions

Study 1:

What are the different complex system-level factors that are associated with hospitals wanting to use remote patient monitoring (telehealth) but not having the resources compared to those that have resources, or are fully adopted?

Study 2:

Mixed Methods Aim:

Explore the forms of telehealth technology services utilized in Nebraska clinics, the challenges faced with adopting telehealth services and the organizational plans for the sustainability of current services.

Mixed Methods Question:

To what extent can the qualitative interviews of telehealth clinical staff contribute to a more comprehensive understanding of the quantitative survey data related to barriers of adoption and subsequent sustainability of telehealth services in Nebraska?

Quantitative:

What forms of telehealth technologies (i.e., live video, store and forward or remote patient monitoring) are being used in Nebraska clinics?

What are the barriers most closely associated with the different forms of telehealth technology?

Qualitative:

What were the decision-making factors for adoption of a telehealth service system?

How are clinics providing telehealth services overcoming the noted barriers from the survey?

What are the plans for continued sustainability?

Study 3:

What is the effect of emotional support and symptom management telehealth on the quality of life (QOL) of cancer patients in treatment and cancer survivors not in active treatment?

Chapter 2: Theory Background

I. Complex Socio-Technical Systems

To understand and influence change in complex socio-technical systems, there must be a basic understanding of the nature of causality in complex systems.[68] Engineered systems have design documentation, such as for aircraft, and the origins and flows of the systems are stated. If a part is malfunctioning, you can go to the design documentation and know the root cause and a way to fix the problem. Complex systems (CS) however occur when you include people and organizations with these engineered systems, then the system can be more prone to error and uncertainties.[68,69] The more complex the system of interest, such as healthcare systems, the more difficult it is to deduce the causes of the systems state. The system through which changes evolve are dynamic and include uncertainties, so we need to better understand the system and the nature of change in a complex system. [68,69]

Utilizing the cause-change relationship mediated by the complex system, you can better understand how one might influence economic or technological changes to facilitate better outcomes. This direction of study is less about the theoretical correctness, but is pragmatic and strongly influenced by the lens of the researcher, in this case, the healthcare system and the adoption of telehealth services.[68] There is no design documentation that will address the sustainability issue of telehealth technology within

differing organizations within a particular time and context, allowing easy access to the solution.

To determine the cause of the outcome, we need to differentiate necessary, sufficient, and contributory causes. A necessary component of fire is oxygen, however for sufficient conditions to be met you need heat, fuel, and oxygen together. Contributing to the success of the fire is the lack of rain.[68] In this example, to adopt a sustainable telehealth program, we need investment in technology, support of services (staff, IT, providers), the demand of services by patients, and reoccurring payments to recoup expenses. As the US population has increased its longevity and increased poor health behaviors, healthcare expenditure has increased.[68] The increased demand for healthcare services has advanced faster than the technology that could make healthcare more cost-efficient. Similarly, reimbursement systems encourage the use of healthcare services yet limits payments for treatments outside of designated facilities. [68]

Telehealth systems are characteristically complex, even in the simplest forms they are socio-technical networks. These networks are made up of patients, caregivers, healthcare professionals, biomedical devices, electronic equipment, and digital contents, all connected to the infrastructures and technology services related to exchanging information and knowledge across distances to provide patient care.[44,59] This network of stakeholders operates within the complex healthcare organizational system and interacts with other players in the system such as CMS and licensing associations.

The telehealth systems, as in most healthcare structures, have vague and badly defined limits and the stakeholders can change and can belong to several systems.[44] Telehealth systems challenge a simple, comprehensive model; they are open dissipative

systems that include complex subsystems nested within each other.[44] These systems show non-linear interactions and connections and are therefore not predictable in the cause-effect relationship. This leads to the categorization of telehealth systems as Complex Socio-Technical Systems (CSTS).[44]

It is often useful to represent complex systems at multiple levels, which could be characterized as a hybrid holistic-reductionist model. Holistic approaches for modeling CS can enable qualitative analysis that provides insights into the sources of complexity. The reductionist approach to modeling CS requires specification of the entities and their relationships in the system's structure and enable the dynamics of the system behavior.[68] There is more to the healthcare system of delivery than patient-provider interactions; there are capabilities and information that can enable this delivery.[68]

Table 2.1: Multilevel Modeling Framework for Healthcare Delivery[69]

Level	**Healthcare Delivery**
Domain Ecosystem	Market Priorities, Medicare/Medicaid
System Structure	Providers, Payers, Suppliers
Delivery Operational	Care Capabilities, Health Information
Work Practices	Patient-Clinician Interactions

Table 2.1 shows the different hierarchical levels within the complex socio-technical system of healthcare. The highest level of the telehealth CSTS model is the Healthcare Ecosystem in Society. This level includes the legal, regulatory, and cultural framework that affect the operation of healthcare organizations in the provision of services. [44] The stakeholders within this level are legislative bodies, administrations, and regulatory agencies, such as CMS, insurance companies, and licensing associations. The

macroeconomic and social policies related to legal measures, regulation, standards, and certification process are established at this level. [44]

The healthcare system structure level is where organizations providing healthcare services and have the capacity and skills to provide telehealth services take action. The operating rules and regulations for the telehealth systems among different healthcare organizations are established at this layer and include rules for reimbursement and economic incentives as well as guidelines for implementation and operation of the systems. [44] The operational level refers to processes that support the provision of telehealth services within the framework of the healthcare organization. This level is dictated by the organizational and operating framework within the health organization, and establishes the general architecture for the telehealth system, such as communication flows between patients and providers and the satisfaction of services that must be covered. [44,69] The lowest level within the CSTS is related to the people involved in the telehealth services. The work practices level incorporates patient perceptions, providers' preferred work style, the daily workflow of the facility and the actual technology that is being used to complete the telehealth services. This is an individual level component. [44,70]

II. Ready, Willing, and Able (RWA)

A model for understanding the adaptation of behavior to new forms of innovation is conceptualized using three preconditions for adaptation. These three preconditions which need to be met, are readiness, willingness, and ability.[71] **Readiness** refers to the fact that the innovation must be advantageous to the actor, the technologies utility must be evident and outweigh the disutility. In the case of telehealth technology, there must be an evident advantage for patient outcomes and a marked return on investment. This process requires

the actor, the organization, and telehealth participants, to first know of the technology and then to process the technology as a positive and needed technology in their current and perceived future internal and external context.[48] **Willingness** is the considerations of legitimacy and normative acceptability of the new technology. [71] In the instance of telehealth technologies, this includes the satisfaction and acceptance of patients and providers, as well as, legitimization by organizations and regulatory agencies. Finally, the actor must have the **ability** to access the new innovation. [71] Ability is the actual operational power of an individual, organization, or community within an amenable external environment to perform a task.[72] Ability in the context of telehealth technology, includes technical capabilities, resources for investment, and overcoming licensing and reimbursement challenges related to telehealth services. The "ready, willing, and able" conceptual model allows us to connect economic, behavioral, and social narratives into one integrated overarching framework.

A qualitative study to determine the meaning of organizational readiness in relation to the adoption of telehealth found several areas that were relevant to perceived readiness within the organization.[73] First was core readiness, which was the realization of dissatisfaction with the present status quo and the realization of a need for the new innovation. Structural readiness is perceived as stability within the organization and preparedness of the organization to take the next step. Structural readiness is seen as the foundational elements (human, technical, policy, and funding) that will be necessary for successful telehealth adoption.[73] This type of stability was seen as necessary for the comfort and confidence of the people involved in the telehealth program. [73] In the RWA

model, the actual structural components would also be part of the organization's ability to perform the services.

This qualitative article used the term readiness to encompass all the preconditions of RWA. However, the cited components are still relevant to RWA after a breakdown into the model. There was a need for written policies in the areas of physician reimbursement, liability, cross-state licensing, and privacy were considered essential, and this would improve the willingness to adopt the telehealth technology.[73] This would legitimize the technology and provide a better understanding of the processes related to the technology at lower levels in the CSTS hierarchy. Study participants also noted funding as an integral element for the implementation of telehealth technologies and the ability to sustain the system.[73] Funding has a cross-level and pre-condition characteristics. Funding at the federal level would be an ecosystem level ability, yet at the same time could be seen as a key component of readiness. Legislation that requires private insurance and Medicaid to reimburse for telehealth services would be an organizational level ability for sustaining the services. All governmental policy could also be seen as a provision of willingness, as legislation would show acceptability of the technology by government agencies.

Along with financial resources, there needs to be technical capabilities in the organization. The appropriate technology capabilities to perform the service of care must be in place.[73] This can include the readiness and willingness of staff to understand the use of the technology and incorporate it into their workflows, and, the ability to train the users of the technology for optimal utilization of the technology. It also requires the

correct equipment, software, hardware, and exchange capabilities for the organization's ability to provide the telehealth intervention.[73]

The RWA model for a healthcare organization is affected by internal and external conditions. The internal conditions of readiness and ability for technology adoption can often be controlled by the organization. However, the necessary ability to adopt telehealth technologies can require considerable time and resources subject to limitations within the organization and external environment. [74] The CSTS model puts the external environment at a higher level, such as the healthcare ecosystem, the organization has less control over the conditions imposed by the external environment.[74] This requires organizations to adapt to the external environmental factors at the level higher than the organizational system and optimize the internal organizational, system, and subsystem level components to adopt and sustain telehealth technologies.

III. Conceptual Framework

The conceptual framework for this dissertation will be an adapted CSTS structure with aspects of the "ready, willing, and able" model. Figure 1 is a combined representation of the RWA theory and the CSTS level model. Each precondition of RWA can be evaluated at the multiple levels of CSTS, to better understand the organizational and environmental factors that affect telehealth adoption. Adoption refers to the decision that the user makes to determine the use of telehealth technology is the best course of action available at that point in time in that context. [48]

Figure 2.1: Conceptual Framework for the Organizational and Environmental Factors that Influence Telehealth Adoption

To evaluate the multiple levels of the conceptual framework for all three preconditions will require the use of multiple studies and datasets. Table 2.2 demonstrates the levels within each necessary precondition for telehealth adoption to occur. Within each level and precondition are variables from each study within this dissertation and where they relate to the conceptual framework. Many variables can overlap in level, and precondition as the system of telehealth is complex and requires many changes in many different areas of healthcare.

Table 2.2: Conceptual Framework with Examined Variables

Level	RWA	Study 1	Study 2	Study 3
Ecosystem (Society)	Ready	• Market Competition • Health Professional Availability • Government Restrictions • Location	• Government Incentive	• Need/Demand
	Willing	• Market Competition	• Government Restrictions • Government Incentive • Reimbursement Barriers	• Legitimization
	Able	• Government Restrictions • Reimbursement Barriers	• Government Restrictions • Government Incentive • Reimbursement Barriers	
System Structure (Organization)	Ready	• Organizational Support • Need/Demand • Location	• Organizational Initiative	
	Willing	• Need/Demand • Location	• Organizational Initiative • Acceptability by professionals	
	Able	• Organizational Support • Need/Demand • Organization Resources	• Organization Resources • Location	
Operational (Within Organizational Processes)	Ready	• Organizational Support	• Health Professional Availability	
	Willing	• Organizational Support • Technology Capabilities	• Accepted Professionally • Need/Demand	
	Able	• Technology Capabilities	• Operational Fit • Reimbursement Barriers	• Multiple processes and forms demonstrated. • Comparable to In-person
Work Practices (People)	Ready		• Recognized Demand/Need	• Initiative to Perform Evaluated Study

	Willing		• Professionally Accepted	• Positive Effect on Patient QOL
	Able		• Personnel Capabilities • Technology Capabilities	• Utilization of Different Staff to Perform Telehealth Services. • Services Provided to Several Cancer Types and Stages of Treatment.

QOL: Quality of Life

For study 1, only 3 of the hierarchical levels are able to be assessed as there is no individual-level data collected with the AHA survey. At the ecosystem level, market competition can relate to both the organization's readiness and willingness to adopt telehealth technology. In highly competitive markets an organization may see technology as an advantage above competitors.[9,50] The use of telehealth technology by competitors may also legitimize the technology for the organization, making the organization more willing to adopt and make the technology part of their normal processes. Patients in a highly competitive market may choose the most innovative facility, believing innovation is equal to quality and the best care. Innovation would be demanded by patients as part of their healthcare service and organizations lacking would see lower patient satisfaction. Health professional availability is part of the readiness to adopt at both the ecosystem and procedures levels. This is because a lack of one form of personnel can lead to a need to adopt, as in the case of a lack of specialist in rural communities. However, a lack of support staff to run the technology would prevent adoption as it would take too much time away from the current staff and not be advantageous to the facility.[1,50,61]

Government restrictions and incentives were put into all three categories within the ecosystem level. This is because of the pervasive nature of government policies. A

government policy that requires extra licensing and accreditation to use telehealth technology would decrease the advantage for certain organization. The time and monetary cost to either become accredited or licensed or hire the appropriately licensed staff may not lead to a high enough ROI.[9] Also organizations may not have the ability to obtain the required licenses and appropriate staff with their current resources. Incentives such as grant funding, however, can greatly improve the readiness and ability to adopt. Government incentives can improve the legitimacy of the technology; the government is funding the innovation which makes organizations more willing and ready to adopt. For patients covered under public insurance, coverage of innovation and the push by the government on provisions of these services can increase patients' acceptance of a new innovation. Similarly, the additional monetary incentives of grants can create the resources needed by the organization to be able to implement these services.

Reimbursement barriers are similar to government restrictions. The fewer barriers in place, the greater the readiness and ability for an organization to use telehealth. At the ecosystem level, this can relate to the parity of reimbursement between in-person and telehealth services, and it may also relate to the type of services that can be reimbursed for. If there is parity in reimbursement, organizations are more likely to adopt and be able to cover costs through reimbursement.[9,31] At the operational process level, barriers can relate to increased denial of claims or coding confusion, this limits the ability of the organization to reclaim costs and sustain the services.[9] Location of the organization also affects several factors at different levels. At the environmental level, location can affect the amount of technology that is used in the market and the normalization of the technology in the profession, impacting the organization's readiness and willingness. It

can impact governmental incentives, as rural organizations often have a higher need and more opportunities for grant funding, increasing their ability to adopt. [9,18] At the structural level, location can determine healthcare professionals availability, technology infrastructure, and cost of investing in technology.

Demand and/or need relate to several levels within the three categories. Need can relate to the organization's patient population who may have a higher need for specialist care or home services. This population would have increased demand for telehealth services, particularly in rural areas.[61] Providers may also demand telehealth technology to increase the organization's competitive edge or to lighten the burden of traveling to multiple work sites. Both of these scenarios increase the readiness and the willingness at the system structure and work practices levels. Lack of specialists and routine referral to specialists may also increase the need of the organization and lend to higher adoption of telehealth technology.[11] These can relate to system processes being willing and able to integrate telehealth as part of their normal referral process. As healthcare systems are a complex socio-technical system, many factors interact with one another and cover multiple levels and categories in relation to the adoption of telehealth use.

Organizational support relates to the known factors of structure that lead to greater incentive to adopt telehealth. Teaching hospitals may have a mission that supports technology advancement compared to other facilities.[9] A study noted that physician groups tend to oppose telehealth adoption for unspecified reasons. [39] Being part of a network can increase the ability of an organization through shared resources.[31] Organizational initiatives were determined in study two with interview questions related to the organizational decision-making process to adopt telehealth. The qualitative

interviews also yielded insights into the current status of technology use and the framing of the future prospects for telehealth services. Operational fit can also link to organizational structure and demand, in that if the process of referral to specialists is in place or technology is abundantly used in different ways within the organization, then telehealth technology may be more acceptable and fit in existing normalized processes.

Technology and personnel capabilities have a big impact on the ability of organizations willingness and ability. Personnel capabilities can also relate to the professional acceptability of technology. Technology capabilities are defined for these studies as the existing technology other than telehealth being used in the facility. The more technology infrastructure and IT capability the more legitimized technology use is, and the organization is likely to see the benefit of technology, and have greater capability to add additional technology, as they do not need to invest from scratch.[9] Often remote patient monitoring systems can link directly to existing EHR systems.[40] Personnel capabilities include the personnel's perception of the usability of the new technology and their familiarity with using technology within their usual work routine. Personnel who find technology hard to work with will resist adoption and limit the organization's ability to implement within their work practices. [61] Personnel, especially physicians, can affect the acceptability of technology within a profession, as is the case in teleradiology. Radiology uses telehealth technology quite frequently with success, and it is now a normative process. This legitimizes the use of telehealth technology in the field of radiology and increases the willingness of other radiology departments to adopt telehealth. [56,62,64,65]

The characteristics of study three are related to the studies within the meta-analysis and systematic review as well as the overall findings. With the great number of studies and with the background of patient need stated within each study, it shows that at the larger level there is a need that is currently not being met by standard usual care. Therefore these studies seek to cover the gap in care and show that these organizations are ready to use telehealth to meet patient needs. These feasibility and randomized controlled trial (RCT) studies help to legitimize the use of telehealth in oncology patient support. With positive outcomes comes the legitimization of a clinical technique. These are at the higher level of the ecosystem as they relate to the entire field in the systematic review and meta-analysis. The ability of these organizations is demonstrated through multiple processes, different forms of telehealth technology, and variety of personnel being used to provide these services to cancer patients and survivors recovering from several different types of cancer. These organizations and researchers took the initiative to evaluate technology use at the work practices level, this relates to the readiness to observe the projected benefits of the technology. Finally, to further legitimize the use of technology at the work practices level is the overall positive effect on survivor and patients quality of life. [75]

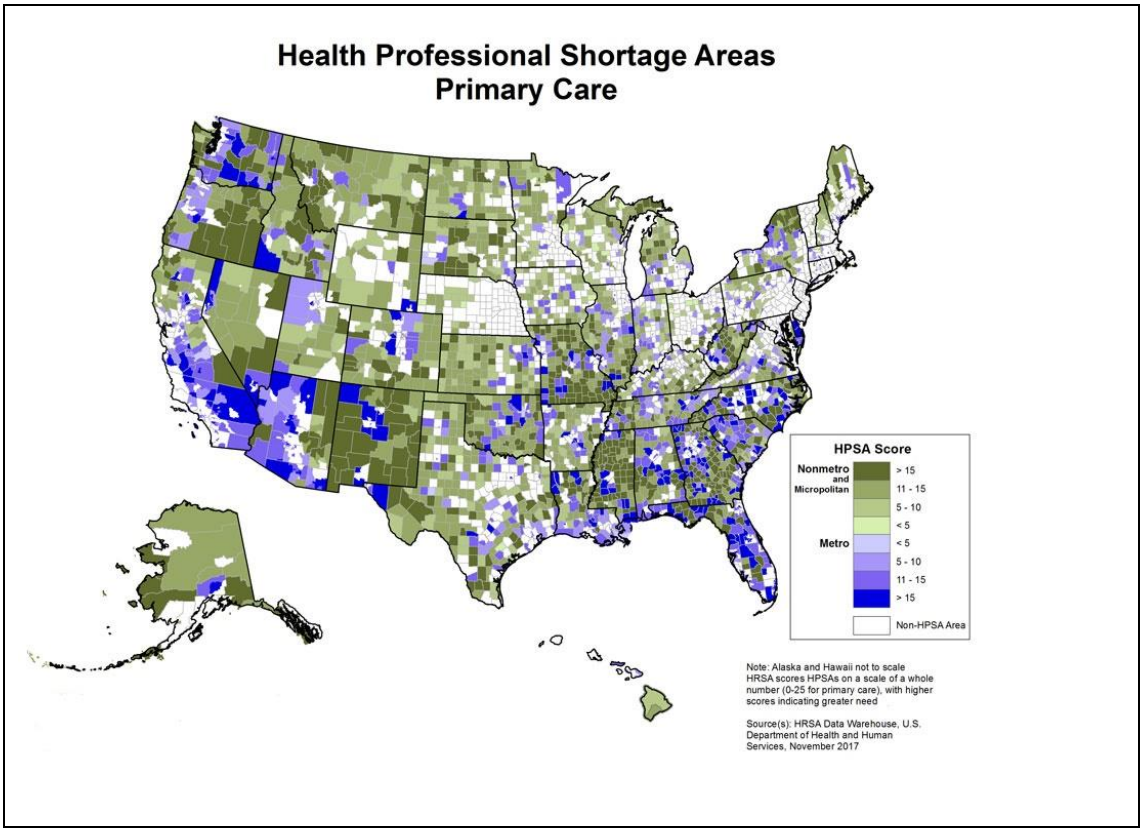
Chapter 3: Organizational and Environmental Factors that are Associated with the Ability to Adopt Telehealth Technology in US Hospitals.

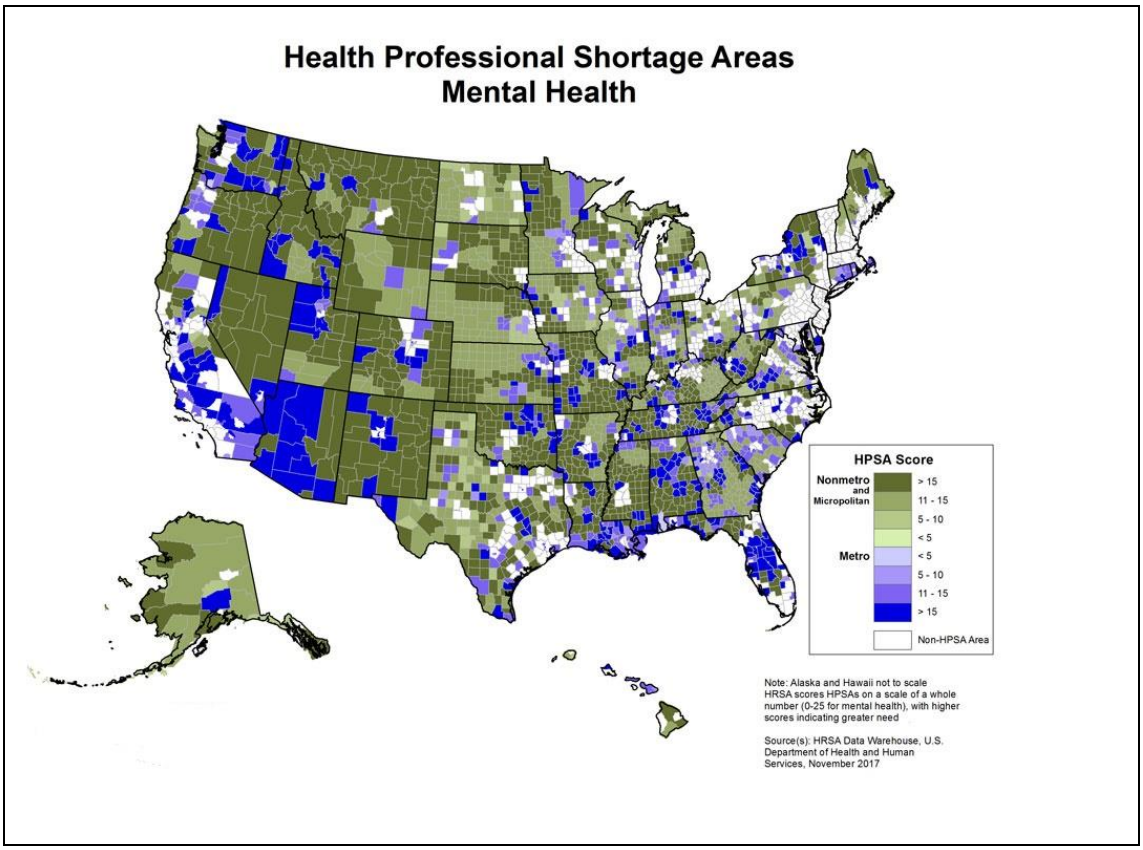
I. Introduction

As of January 1, 2018, there are over 7,000 primary medical health professional shortage areas (HPSA) in the US. Along with approximately 5,000 mental health

HPSAs.[76] Rural and partially rural areas make up 66% of primary medical HPSAs and 62% of mental health HPSAs.[76] These shortages are likely to continue to deteriorate as the expected primary care physician deficiency hits approximately 124,000 in 2025.[76] Telehealth may be a way to access care more efficiently from these predominantly rural shortage areas.

Figure 3.1 Health Professional Shortage Areas by Geographic Designation[77]





This study seeks to fill a gap in the literature on the multi-level factors that lead to a lack of resources despite the intent to adopt telehealth technology. Although there have been previous studies that have tried to use organizational factors as predictors of adoption, [9,67] this study seeks to find the association between contextual factors with the different levels and preconditions of ready, willing, and able. Every organization has a different complex system, made up of different ecosystem, organization, and process level factors. The purpose of this study is to answer the research question: What are the different complex system-level factors that are associated with hospitals wanting to use remote patient monitoring (telehealth) but not having the resources compared to those that have resources, or are fully adopted? By utilizing a national database, a broad range of hospitals can be analyzed which can help with better understanding of the factors that

are particularly associated with adoption and those that may be associated with not having resources(ability) or not having the intent (readiness and/or willingness).

II. Methods

This study utilizes the 2015 American Hospital Association Annual Survey database (AHA) and information technology (IT) supplement survey. This national dataset addresses the RWA factors at the higher levels of the CSTS hierarchy. The database is a comprehensive hospital database intended for health services research and market analysis. The survey responses are from hospitals within the AHA, but also non-registered hospitals identified through associations, CMS, and other organizations. Data are supplemented with data from the AHA registration database, the US Census Bureau, hospital accrediting bodies, and other organizations. [78] The AHA Annual Survey IT supplement is sent to the chief executive officer of each US hospital, and the person who is most familiar with the organization's HIT was asked to complete the survey. Although the survey is meant to measure the implementation and adoption of US DHHS Meaningful Use, the survey includes functional HIT questions. [79] The response rate for the AHA Annual Survey is at or near 80%, totaling 5, 564 for hospitals in the US excluding outside territories. [78] The 2015 AHA IT supplement survey had a total of 3,538 responding hospitals. [79]

Within the AHA IT supplement survey there are questions about the implementation of both telehealth and remote patient monitoring. The survey answers are given on a six-level Likert scale denoting the status of implementation and intent. [79]

"Does your hospital currently have a computerized system which allows for:" [79]

1. Telehealth
2. Remote Patient Monitoring

Likert scale answers:

- Fully implemented across all units
- Fully implemented in at least one unit
- Beginning to implement in at least one unit
- Have resources to implement in the next year
- Do not have resources but considering implementing
- Not in place and not considering implementing

The first three categories (fully implemented across all units, fully implemented in at least one unit, and beginning to implement in at least one unit) are organizations who have met all three preconditions to adopt the innovation. The process has been completed or started, meaning they have the designated structural, technological, and organizational ability necessary to implement the chosen telehealth technology. The fourth category, "have the resources to implement in the next year," are presumed to have met the three preconditions, but the ability is still in development as the organization is waiting until the following year. The category that is of most interest in this study is that of the organizations that do not "have the resources but are considering implementation." In this instance, the actor has met the ready and willing preconditions but does not have the ability. This leads to the question, what multilevel factors affect the hospitals' ability to adopt when the perceived utility, need, and normalization of the technology pre-conditions have been met, particularly in contrast to those that have met all three conditions? Finally, those that are not considering implementation lack the first

precondition of readiness, there is no perceived need or utility and therefore regardless of willingness or the ability of the organization (actor) the process of adopting the innovation will not continue.

For the two multivariate logistic regression analyses, both telehealth and RPM categories were coded the same. The first analysis is the group who reported "Do not have resources but considering implementing" compared to the first four answers all of which have either implemented, started implementing or have the resources to implement. The second multivariate logistic regression analysis compared the group that does not have the resources with those that are not interested, "Not in place and not considering implementing." Univariate analysis was done for all variables used in each multivariate model. The ordered logistic regression combines these three groupings into one regression model. For the ordered logistic regression, those hospitals without intent or interest were the 1st level used as the comparison group, those without resources were the 2nd level, and the first 4 levels that met the preconditions for RWA were grouped together as the 3rd level, being the highest level of implementation. Tabulations and chi-square testing were also done to determine initial association and note small cell size.

Also pulled from the AHA IT Supplemental Survey was information on two other technology capabilities, provider portal, and secure messaging capabilities. [79]

"When a patient transitions to another care setting or organization outside your hospital system, how does your hospital routinely send and/or receive a summary of care record?" (more than one answer was allowed) [79]

1. Provider Portal (i.e., post to portal or download from portal)
2. Secure messaging using EHR (via DIRECT or other secure protocol)

a. Send

b. Receive

c. Neither send nor receive

d. Do Not Know

The variables used within the data analysis that were collected via the AHA Annual Survey were answers to the following survey questions: [78]

1. Control: Indicate the type of organization that is responsible for establishing policy for overall operation of your hospital.
    a. Government, nonfederal
    b. Government, federal
    c. Investor-owned, for-profit
    d. Nongovernment, not-for profit
2. Service: Indicate the ONE category that BEST describes your hospital or the type of service it provides to the MAJORITY of patients:

    General

    a. General medical and surgical
    b. Hospital unit of an institution (prison hospital, college infirmary)
    c. Acute long-term care hospital

    Psychiatric and Disabled

    d. Hospital unit within a facility for persons with intellectual disabilities
    e. Psychiatric
    f. Intellectual disabilities
    g. Alcoholism and other chemical dependency

Specialty

h. Surgical

i. Tuberculosis and other respiratory diseases

j. Cancer

k. Heart

l. Obstetrics and gynecology

m. Eye, ear, nose, and throat

n. Rehabilitation

o. Orthopedic

p. Chronic disease

q. Other - specify treatment area:

Pediatrics

r. Children’s general medical and surgical

s. Children’s hospital unit of an institution

t. Children's psychiatric

u. Children’s tuberculosis and other respiratory diseases

v. Children’s eye, ear, nose and throat

w. Children’s rehabilitation

x. Children’s orthopedic

y. Children’s chronic disease

z. Children’s other specialty

aa. Children’s acute long-term Care

3. Network: Is the hospital a participant in a network?

   a. Yes
   b. No

4. Physician Group: Is your hospital owned in whole or in part by physicians or a physician group?
   a. Yes
   b. No
5. Total Beds: Beds set up and staffed for use at the end of the reporting period?
6. EHR: Does your hospital have an electronic health record?
   a. Yes, fully implemented
   b. Yes, partially implemented
   c. No
7. Census Division: Determined from reported hospital address.
   a. New England: (ME, NH, VT, MA, RI, CT)
   b. Mid-Atlantic: (NY, NJ, PA)
   c. South Atlantic: (DE, MD, DC, VA, WV, NC, SC, GA, FL)
   d. East North Central: (OH, IN, IL, MI, WI)
   e. East South Central: (KY, TN, AL, MS)
   f. West North Central: (MN, IA, MO, ND, SD, NE, KS)
   g. West South Central: (AR, LA, OK, TX)
   h. Mountain: (MT, ID, WY, CO, NM, UT, NV)
   i. Pacific: (WA, OR, CA, AK, HI)
8. Core Based Statistical Area Type: Determined from reported hospital address.
   a. Metropolitan

b. Micropolitan

c. Rural

The secure messaging variable was coded to have three groupings instead of four, due to the smaller number of observations with send only or receive only responses. Send only or receive only, were coded as one group. Those that had both capabilities, to send and receive were coded as one group, and those with neither capability were the 3rd category. Provider portal was categorized the same way as for secure messaging. Control was regrouped due to the small amount of government non-federal hospitals in the dataset. Both government controlled hospital categories were combined. For service survey responses, AHA has suggested coding for grouping, as noted above in the available responses to the question. Again there were a limited number of pediatric responses, so the pediatric facilities were divided the same as general services, creating three groups (General, Psychiatric and Disabled, and Specialty).

The network and physician group variables were left as is, as they were binary responses. Total bed counts were recorded in the survey responses and were then categorized into 7 groupings. These groupings were determined by first using the suggested categories in the AHA Survey Codebook appendix.[78] The highest two ranges were then combined due to small numbers of observations of hospitals with 500 or more beds. The EHR capabilities of the hospital were grouped as a binary variable, those that had implemented fully or partially were combined and compared with those that did not have EHR implemented. Teaching hospitals were designated using the suggested format given in the AHA Survey codebook, as the designation is not determined by one factor but multiple fields.[78]

The hospital location was used to derive the census division and the statistical area. The census divisions were left according to the groupings used by the census bureau and provided in the AHA Survey codebook. [78] The only change was the combining of the New England and Mid-Atlantic divisions. The need to combine these two categories was determined through initial analysis and descriptive statistics. The statistical area was designated within the survey codebook. Metropolitan statistical areas have a population of more than 50,000 people, while micropolitan areas have between 10,000 to 50,000 people.[78] Rural areas, which have less than 10,000 people, and micropolitan areas were combined in this analysis, due to the fact that micropolitan areas are still labeled rural in AHA data offerings.[78] Observations missing any of the independent variable responses were removed from the final analyzed data set.

The AHA survey and IT supplement were merged via unique facility codes. Policy and reimbursement legislative variables were created by using the Center for Connected Health Policy's "State Telehealth Laws and Reimbursement Policies: A Comprehensive Scan of the 50 States and District of Columbia."[17] The legislation provided in this report were examined and recorded in different technology categories that are reimbursable by private insurance and Medicaid. Each analysis was run with individual technology type (live video, store and forward, and RPM) reimbursement provided categories for both Medicaid and private insurance. The final models contain a private insurance and Medicaid insurance categorical variable on the number of technologies that legislation requires reimbursement for, as this was found to be more consistent and was comparable to the three individual technology categories for each type of insurance. The legislative requirements for additional licensure and/or patient consent

were also included as additional variables for telehealth policy. These data were merged with the AHA survey and IT supplement for each state.

To inform on ecosystem-level factors the Health Professional Shortage Area (HPSA) data was utilized, which is provided by the Health Resources and Services Administration (HRSA). This data contains information on areas that have a shortage of healthcare providers.[80] There are three different types of provider shortage areas, primary care, dental health, and mental health shortage areas. Shortage areas can refer to geographic areas, or population groups and healthcare facilities, such as Federally Qualified Health Centers.[80] Not every hospital has a HPSA score for each domain as not every shortage area is deficient in all types of providers. However, some areas are lacking in all three healthcare providers. To deal with the multiple HPSA scores, an average of scores was used to determine association with level of implementation.

Sensitivity analysis was run to determine if individual shortage areas by service type were significantly associated with the level of implementation, but none were significant independently and logistic regression analysis with individual level or averaged scores yielded a similar outcome. Primary care and mental health care HPSA scores range from 0-25, while dental health HPSA scores max out at 26. [80] The scores are based on several indicators of healthcare professional shortage including patient to provider ratios. The higher the score, the greater the lack of healthcare professionals to serve the needs of the population. [80]

To analyze the characteristics of the patient population surrounding the hospitals the Area Deprivation Index (ADI) was used. The ADI measures the socioeconomic deprivation experienced by a neighborhood located within a geographical area.[81] The

original index was developed using 17 different indicators of socioeconomic status from the 1990 Census data. This index has more recently been updated by the Health Innovation Program at the University of Wisconsin-Madison, which now uses 2000 census block group-level data and the original coefficients from 1990. [81] The variables included in the index are:

- Percent of the population aged 25 and older with less than 9 years of education
- Percent of the population aged 25 and older with at least a high school diploma
- Percent employed persons aged 16 and older in white-collar occupations
- Median family income in US dollars
- Income disparity
- Median home value in US dollars
- Median gross rent in US dollars
- Median monthly mortgage in US dollars
- Percent of owner-occupied housing units
- Percent of civilian labor force population aged 16 years and older who are unemployed
- Percent of families below federal poverty level
- Percent of the population below 150% of the federal poverty threshold
- Percent of single-parent households with children less than 18 years of age
- Percent of households without a motor vehicle
- Percent of households without a telephone

- Percent of occupied housing units without complete plumbing
- Percent of households with more than 1 person per room

The data uses 9-digit zip codes to identify each area and provide a score that indicates the level of deprivation. [81] However, to merge both the HPSA and ADI data with the AHA surveys combined data, 5-digit zip codes were used, as some hospital address information only had 5-digit zip codes instead of nine. The higher the score, the higher the level of deprivation in that area. The index is set to have a mean of 100 and a standard deviation of 20. The dataset contains over 30 million entries, and although it is from the 2000 census, there is only a very small percentage of new zip codes that are not included due to being new. Similarly, 0.1% of zip codes were removed due to insufficient data. [81]

Finally, the data from the Dartmouth Atlas of Health Care was merged with the previous datasets to determine hospital service areas (HSAs).[82] The HSAs are the markets associated with the hospital and are determined from a collection of zip codes of the patients who frequent the hospital the most. [82] The HSAs were created by utilizing Medicare patient data to determine the greatest proportion that were hospitalized at a facility, then minor adjustment for geographic differences were made to equate to 3,436 HSAs. [82] The HSAs were used to calculate the Herfindahl-Hirschman Index (HHI). The first step in calculating the HHI was done by determining the total beds for all hospitals within a HSA. Then the proportion of beds for each hospital in the designated HSA was calculated. The total bed proportions, also known as market proportions, were squared and then summed to identify that area's HHI. The HHI totals were then categorized into competitive market, having the lowest scores (<1,500), increasing in concentration from

moderate (1,500-2,500) to high (2,501-9,999), with monopoly being the highest possible score (10,000).

Table 3.1 puts each variable used within the study in the context of the hybrid framework of RWA and CSTS theories. Due to the high level of the data collected, the individual work practices of the lowest level of the CSTS cannot be determined.

Table 3.1: Hybrid Framework with Independent Variables for Study 1

LEVEL	READY	WILLING	ABLE
ECOSYSTEM (SOCIETY)	HHI, HPSA, Reimbursement Policy, Division	Legislation	Medicaid and Private Reimbursement
SYSTEM STRUCTURE (ORGANIZATION)	Physician Group Ownership, ADI, Rurality, Teaching Hospital	Hospital Ownership, Licensing, Consent	Provider Characteristics: Part of a Network, Size (Total Beds)
OPERATIONAL (PROCESSES)	Hospital Ownership	Part of a Network, EHR Status, Primary Service Specialty	Health Information System (Secure Messaging and Patient Portal)

HHI: Herfindahl-Hirschman Index; HPSA: Health Professional Shortage Area; ADI: Area Deprivation Index; EHR: Electronic Health Record

III. Results:

Table 3.2 provides frequencies for the different levels of telehealth and RPM implementation in the dataset after adjusting for missing values. The original dataset contained a total of 3,466 uniquely identified hospitals after merging the AHA dataset with the IT supplement, Health Professional Shortage Area data, and the Dartmouth College Hospital Service Area (HSA) data. The same organizational and environmental factors were run for both types of technology that were surveyed. The telehealth data are

more general, due to the fact that telehealth was not defined within the survey. RPM is a form of telehealth and this provides more precise information about a certain type of technology that is used and how it is used. All analysis was done with STATA 14 software.[83]

Table 3.2: Telehealth and RPM Implementation Category Frequencies

Telehealth Categories (N = 2,213)	**Frequency (%)**
Fully Implemented across all units	462 (20.9%)
Fully implemented in at least one unit	828 (37.4%)
Beginning to implement in at least one unit	214 (9.7%)
Have resources to implement in the next year	157 (7.1%)
Do not have resources but considering it	259 (11.7%)
Not in place and not considering implementation	293 (13.2%)
Total	2,213 (100%)
Remote Patient Monitoring Categories (N= 2,181)	**Frequency (%)**
Fully Implemented across all units	392 (17.9%)
Fully implemented in at least one unit	505 (23.2%)
Beginning to implement in at least one unit	191 (8.8%)
Have resources to implement in the next year	183 (8.4%)
Do not have resources but considering it	406 (18.6%)
Not in place and not considering implementation	504 (23.1%)
Total	2,181 (100%)

Telehealth Results

Table 3.3: Multilevel Variables Tabulation and Chi-square for Telehealth (N=2,213)

Independent Variable	**Independent Category**	**Fully implemented across all units (n=581)**	**Fully implemented in at least one unit (n=581)**	**Beginning to implement in at least one unit (n=273)**	**Have resources to implement in the next year (n=196)**	**Do not have resources but considering it (n=346)**	**Not in place and not considering implementation (n=390)**	**Pearson χ^2**
Private Insurance								20.0*
	No private payer requirements	182	291	72	39	85	91	

	At least one form of telehealth is required	62	145	34	31	32	47	
	All three forms are required	218	392	108	87	142	155	
Medicaid Insurance								16.5
	No Medicaid payer requirements	15	10	5	4	6	5	
	At least one form of telehealth is required	356	654	168	131	208	250	
	All three forms are required	91	164	41	22	45	38	
Metro/Rural								3.53
	Metro	316	550	143	113	174	208	
	Rural/Micro	146	278	71	44	85	85	
Patient Consent Required								39.3**
	No	255	506	120	71	136	123	
	Yes	207	322	94	86	123	170	
Physician Required to have state license								8.9
	No	344	635	151	122	179	222	
	Yes	118	193	63	35	80	71	
Area Deprivation Index Categorized								42.7*
	≤ 90	75	137	34	25	38	46	
	91-100	98	160	32	27	33	44	
	101-105	55	119	20	20	35	38	
	106-110	77	143	37	44	63	65	
	111-115	104	116	52	21	49	59	
	>115	53	103	39	20	41	41	
Census Division								96.7**
	NE &Mid-Atlantic	61	91	34	20	50	38	
	South Atlantic	74	162	24	21	24	39	
	East North Central	66	147	30	28	55	40	
	East South Central	26	42	19	10	18	23	
	West North Central	87	106	37	12	35	40	
	West South Central	73	114	42	37	46	70	
	Mountain	37	54	11	9	12	19	
	Pacific	38	112	17	20	19	24	

Part of a Network								89.4**
	No	232	446	99	96	178	228	
	Yes	230	382	115	61	81	65	
Has an EHR								94.7**
	No	41	78	18	27	59	81	
	Fully or partially	421	750	196	130	200	212	
Secure Messaging Capabilities								199.8**
	Both	322	532	104	82	100	108	
	Send only or Receive Only	86	177	58	34	61	59	
	Neither	54	119	52	41	98	126	
Provider Portal Capabilities								218.2**
	Both	201	314	68	44	46	25	
	Send only or Receive only	107	210	49	37	62	39	
	Neither	154	304	97	76	151	229	
Organization Control								225.6**
	Government, non-federal and Federal	88	173	52	27	77	78	
	Non-government, non-profit	338	539	146	102	134	92	
	Investor-owned, for-profit	36	116	16	28	48	123	
Primary Service Provided								412.9**
	General	428	793	193	130	197	153	
	Psychiatric/Disabled	22	14	10	14	32	42	
	Specialty	12	21	11	13	30	98	
Physician Ownership								63.8*
	No	457	809	207	146	250	260	
	Yes	5	19	7	11	9	33	
Total Beds								135.4**
	0-24	45	47	26	12	27	30	
	25-49	77	132	43	37	66	68	
	50-99	75	122	34	25	49	95	
	100-199	99	201	43	36	48	59	
	200-299	55	114	27	19	32	17	
	300-399	38	78	22	15	16	11	
	400≤	73	134	19	13	22	11	
Teaching Hospital/Academic Center								46.9**

	No	243	433	132	86	170	210	
	Yes	219	395	82	71	89	83	
HPSA Average Score								37.9**
	0	351	606	149	121	182	205	
	1-10	30	49	12	9	13	38	
	11-15	42	66	26	12	21	21	
	15 and above	39	107	27	15	43	29	
HHI Categories								26.5*
	Competitive	40	73	21	123	20	30	
	Moderately Concentrated	39	60	20	8	16	23	
	Highly Concentrated	156	268	63	62	95	130	
	Monopoly	227	427	110	75	128	110	

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index
***** $p < 0.05$
** $p < 0.001$

Table 3.3 summarizes the independent variables that were significantly associated with the level of telehealth implementation. The independent variables of the logistic regression were used as the dependent variable in the chi-square testing. This gave a sense to the association between these factors and the differences in implementation levels.

Table 3.4: Telehealth Univariate Analysis of Independent Multilevel Covariates (Hospitals not considering implementation compared to hospitals considering but no resources) (n=552)

Independent Variable	**Independent Category**	**Odds Ratio**	**Robust Std Error**	**z**	***p*>|z|**	**95% Confidence Interval**
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.729	0.200	-1.15	0.250	(0.426, 1.249)
	All three forms are required	0.981	0.187	-0.10	0.919	(0.675, 1.425)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA

	At least one form of telehealth is required	0.693	0.425	-0.60	0.550	(0.208, 2.307)
	All three forms are required	0.987	0.636	-0.02	0.984	(0.279, 3.493)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro	1.195	0.221	0.97	0.334	(0.832,1.717)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes*	0.654	0.112	-2.47	0.014	(0.467,0.917)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	1.397	0.268	1.75	0.081	(0.960, 2.035)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.908	0.289	-0.30	0.761	(0.487, 1.694)
	101-105	1.115	0.358	0.34	0.735	(0.594, 2.092)
	106-110	1.173	0.331	0.57	0.571	(0.675, 2.039)
	111-115	1.005	0.294	0.02	0.985	(0.567, 1.784)
	>115	1.211	0.377	0.61	0.540	(0.657, 2.229)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic*	0.468	0.158	-2.25	0.024	(0.241, 0.906)
	East North Central	1.045	0.313	0.15	0.883	(0.581, 1.879)
	East South Central	0.595	0.227	-1.36	0.173	(0.282, 1.257)
	West North Central	0.665	0.210	-1.29	0.197	(0.358, 1.236)
	West South Central*	0.499	0.143	-2.42	0.016	(0.284, 0.877)
	Mountain	0.480	0.205	-1.72	0.086	(0.208, 1.109)
	Pacific	0.602	0.226	-1.35	0.176	(0.288, 1.256)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes*	1.596	0.310	2.41	0.016	(1.090, 2.337)
Has an EHR						
	No					
	Fully or partially	1.295	0.256	1.31	0.191	(0.879, 1.908)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only	1.116	0.256	0.48	0.631	(0.712, 1.751)
	Neither	0.840	0.163	-0.90	0.368	(0.575, 1.228)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only	0.864	0.278	-0.45	0.650	(0.460, 1.624)
	Neither**	0.358	0.097	-3.80	<0.001	(0.211, 0.608)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA

	Non-government, non-profit	1.475	0.310	1.85	0.064	(0.977, 2.228)
	Investor-owned, for-profit*	0.395	0.093	-3.96	<0.001	(0.250, 0.626)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled*	0.592	0.153	-2.03	0.042	(0.357, 0.982)
	Specialty**	0.238	0.056	-6.11	<0.001	(0.150, 0.377)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes**	0.283	0.110	-3.26	0.001	(0.133, 0.605)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	1.078	0.342	0.24	0.812	(0.580, 2.007)
	50-99	0.573	0.183	-1.75	0.081	(0.307, 1.070)
	100-199	0.855	0.292	-0.37	0.711	(0.464, 1.690)
	200-299	1.871	0.736	1.59	0.111	(0.866, 4.044)
	300-399	1.616	0.765	1.01	0.311	(0.639, 4.088)
	400≤	2.222	1.011	1.75	0.079	(0.911, 5.422)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes	1.325	0.244	1.52	0.127	(0.923, 1.901)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10*	0.385	0.130	-2.83	0.005	(0.199, 0.746)
	11-15	1.126	0.366	0.37	0.714	(0.595, 2.131)
	15 and above*	1.670	0.436	1.96	0.050	(1.000, 2.787)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	1.009	0.331	0.03	0.978	(0.530, 1.920)
	Highly Concentrated	1.005	0.253	0.02	0.983	(0.613, 1.647)
	Monopoly†	1.658	0.433	1.94	0.053	(0.994, 2.766)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Not in place and not considering implementation (NPNC), 1= No resources but considering implementation (NRCI)

***** $p < 0.05$

** $p < 0.001$

†Marginally significant (0.051-0.060)

NA-Not Applicable, Comparison Group

Table 3.4 shows the results from the univariate logistic regression that compares hospitals that do not intend to implement, either not ready and/or willing, and those hospitals that are ready and willing but unable to implement due to lack of resources. This logistic regression informs on some of the CSTS multi-level factors that are

associated with lacking the ability when compared to those potentially lacking all three RWA preconditions. The odds of considering implementing but having no resources when additional patient consent is required is lower when compared to not requiring consent. When consent is required, there are higher odds of not having telehealth and not considering its implementation. As additional consent is another barrier to get through to implement telehealth, this could be related to the lack of readiness in some hospitals.

The different census divisions were compared to the New England and Mid-Atlantic category. All divisions had lower odds of being a NRCI hospital other than East North Central. This may be due to close geographic proximity. However, the only significant differences in odds ratios were for the South Atlantic region when compared to the New England (NE) and Mid-Atlantic region and the West South Central region compared to NE and Mid-Atlantic region. These South Atlantic and West South Central regions were approximately 50% less likely (53.2% and 50.1%, respectively) than the NE and Mid-Atlantic region to be a NRCI hospital.

If a hospital is part of a network, the odds of NRCI are 60% higher than those not in a network. General healthcare service was used as the comparison group for primary service type. Both psychiatric services and specialty services had lower odds of being a NRCI hospital when compared to general healthcare services. Particularly those hospitals in the specialty group, which are 71.7% less likely than general. This may relate back to general care providers not having specialists on hand to fulfill that need, where specialists may not see the need for telehealth services. If the hospital had physician group ownership, the odds were greater that they would be a NPNC hospital. This coincides

with previous studies that found that physician groups tend to be a barrier for telehealth implementation.

HPSAs in the lowest average HPSA score category and in the highest average HPSA score range were both statistically significant. Those in the lowest range score, where the shortage is not as severe, were less likely to be a NRCI hospital. Whereas those hospitals in the highest shortage areas, 1.67 times more likely than those not in shortage areas to be a NRCI facility. A monopoly is 1.7 times more likely to be a NRCI hospital than a competitive market. Potentially markets with only one hospital could be rural areas or underserved areas where that hospital is a fail-safe hospital with limited revenue potential.

For both binary dependent telehealth categories that are used in the univariate analysis, binomial logistic regression was performed. Table 3.5 shows the analysis results from the multivariate logistic regression for those hospitals that were either NPNC or NRCI.

Table 3.5: Telehealth Multivariate Analysis of Independent Multilevel Covariates (Hospitals with no interest compared to hospitals with interest but no resources) (n=552)

Independent Variable	**Independent Category**	**Odds Ratio**	**Robust Std Error**	**z**	***p*>|z|**	**95% Confidence Interval**
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.515	0.229	-1.49	0.136	(0.216, 1.232)
	All three forms are required	0.580	0.183	-1.73	0.083	(0.313, 1.075)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA

	At least one form of telehealth is required	2.322	1.545	1.27	0.205	(0.630, 8.553)
	All three forms are required†	4.571	3.616	1.92	0.055	(0.970, 21.516)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro	0.872	0.249	-0.48	0.632	(0.498, 1.527)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes	0.967	0.353	-0.12	0.905	(0.464, 1.973)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	1.338	0.374	1.04	0.298	(0.773, 2.315)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.803	0.299	-0.59	0.555	(0.388, 1.664)
	101-105	0.957	0.353	-0.12	0.905	(0.464, 1.973)
	106-110	1.046	0.387	0.12	0.903	(0.507, 2.160)
	111-115	0.721	0.284	-0.83	0.406	(0.333, 1.559)
	>115	1.048	0.420	0.12	0.906	(0.478, 2.300)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic†	0.419	0.193	-1.88	0.060	(0.170, 1.036)
	East North Central	0.809	0.322	-0.53	0.594	(0.371, 1.766)
	East South Central	0.431	0.234	-1.55	0.121	(0.149, 1.250)
	West North Central*	0.381	0.187	-1.96	0.050	(0.145, 0.998)
	West South Central	0.751	0.322	-0.67	0.504	(0.325, 1.739)
	Mountain	0.358	0.200	-1.84	0.065	(0.120, 1.067)
	Pacific	0.580	0.328	-0.97	0.335	(0.191, 1.755)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes	1.209	0.289	0.80	0.426	(0.758, 1.930)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially	0.740	0.196	-1.14	0.256	(0.440, 1.244)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only	1.101	0.307	0.35	0.729	(0.638, 1.902)
	Neither	1.306	0.321	1.09	0.277	(0.807, 2.114)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only	0.943	0.361	-0.15	0.879	(0.445, 1.998)
	Neither *	0.461	0.151	-2.35	0.019	(0.251, 0.882)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA

	Non-government, non-profit	1.459	0.372	1.48	0.139	(0.885, 2.404)
	Investor-owned, for-profit	0.755	0.237	-0.89	0.372	(0.408, 1.398)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled	0.722	0.270	-0.87	0.384	(0.347, 1.502)
	Specialty *	0.370	0.126	-2.92	0.004	(0.190, 0.722)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes	0.425	0.226	-1.55	0.121	(0.195, 1.210)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	0.967	0.355	-0.090	0.928	(0.471, 1.988)
	50-99	0.579	0.221	-1.430	0.152	(0.274, 1.223)
	100-199	0.662	0.275	-0.990	0.321	(0.293, 1.495)
	200-299	1.193	0.598	0.350	0.724	(0.447, 3.185)
	300-399	1.195	0.672	0.320	0.751	(0.397, 3.600)
	400≤	1.092	0.650	0.150	0.883	(0.340, 3.505)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes	0.751	0.196	-1.09	0.274	(0.450, 1.254)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10**	0.266	0.108	-3.27	0.001	(0.120, 0.587)
	11-15	1.258	0.462	0.63	0.531	(0.613, 2.583)
	15 and above	1.528	0.518	1.25	0.212	(0.786, 2.971)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	0.931	0.360	-0.19	0.853	(0.436, 1.985)
	Highly Concentrated	0.885	0.284	-0.38	0.703	(0.471, 1.660)
	Monopoly	0.860	0.329	-0.40	0.688	(0.404, 1.819)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Not in place and not considering implementation (NPNC), 1= No resources but considering implementation (NRCI)

***** $p < 0.05$

** $p < 0.001$

†Marginally significant (0.051-0.060)

NA-Not Applicable, Comparison Group

The results for the multivariate analysis of NPNC and NRCI facilities are presented in Table 3.5. Multivariate logistic regression allowed for the control of confounding factors. When all other variables are constant, the only region that has a statistically significant odds ratio is West North Central when compared to the NE and

Mid-Atlantic region. As was found in the univariate analysis, Table 3.4, all regions have odds ratios that make being a NRCI hospital less likely than compared to the NE and Mid-Atlantic region. A hospital that has neither the capability to send nor receive data through a provider portal have lower odds (53.7% less) of being a NRCI compared to hospitals that have both capabilities. Hospitals that are categorized as specialty for the primary service provided are 63% less likely to be a NRCI hospital compared to those categorized as general primary service. A HPSA average score of one to ten had a statistically significant odds ratio that made it even less likely than those facilities with no HPSA average score to be a NRCI hospital. This may be explained by the large amount of zero scores in the HPSA average score data.

Table 3.6: Telehealth Univariate Analysis of Independent Multilevel Covariates (Hospitals that have resources to implement or have implemented compared to hospitals considering implementation with no resources) (n=1,920)

Independent Variable	Independent Category	Odds Ratio	Robust Std Error	z	*p*>|z|	95% Confidence Interval
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.808	0.178	-0.97	0.334	(0.525, 1.244)
	All three forms are required	1.212	0.179	1.30	0.193	(0.908, 1.618)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.900	0.404	-0.23	0.815	(0.373, 2.172)
	All three forms are required	0.802	0.377	-0.47	0.639	(0.319, 2.017)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro	1.017	0.145	0.12	0.906	(0.769, 1.344)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes	1.214	0.163	1.45	0.147	(0.934, 1.579)

Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes *	1.368	0.199	2.15	0.032	(1.027, 1.822)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.742	0.187	-1.18	0.237	(0.453, 1.217)
	101-105	1.166	0.293	0.61	0.541	(0.712, 1.910)
	106-110	1.493	0.331	1.881	0.071	(0.966, 2.306)
	111-115	1.019	0.235	0.08	0.936	(0.648, 1.602)
	>115	1.360	0.331	1.26	0.206	(0.845, 2.190)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic**	0.352	0.093	-3.94	<0.001	(0.209, 0.591)
	East North Central	0.836	0.181	-0.83	0.408	(0.547, 1.277)
	East South Central	0.765	0.230	-0.89	0.373	(0.424, 1.380)
	West North Central*	0.560	0.143	-2.16	0.031	(0.372, 0.954)
	West South Central	0.712	0.160	-1.51	0.131	(0.460, 1.106)
	Mountain *	0.445	0.153	-2.36	0.018	(0.228, 0.871)
	Pacific *	0.419	0.121	-3.02	0.002	(0.238, 0.736)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes**	0.504	0.072	-4.80	<0.001	(0.381, 0.667)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially **	0.371	0.063	-5.84	<0.001	(0.267, 0.518)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only **	1.787	0.310	3.31	0.001	(1.271, 2.512)
	Neither **	3.832	0.605	8.51	<0.001	(2.812, 5.222)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only **	2.097	0.430	3.61	<0.001	(1.404, 3.133)
	Neither **	3.262	0.579	6.66	<0.001	(2.303, 4.620)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit **	0.526	0.082	-4.12	<0.001	(0.388, 0.714)
	Investor-owned, for-profit	1.081	0.221	0.38	0.702	(0.724, 4.615)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled**	4.180	0.968	6.17	<0.001	(2.655, 6.582)
	Specialty**	4.125	0.982	5.95	<0.001	(2.587, 6.576)
Physician Ownership						
	No	NA	NA	NA	NA	NA

	Yes	1.388	0.519	0.88	0.381	(0.667, 2.886)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	1.100	0.277	0.38	0.706	(0.671, 1.801)
	50-99	0.822	0.242	-0.31	0.756	(0.551, 1.542)
	100-199	0.597	0.156	-1.97	0.049	(0.357,0.998)
	200-299	0.717	0.204	-1.17	0.241	(0.411, 1.250)
	300-399 *	0.504	0.170	-2.03	0.042	(0.260, 0.975)
	400≤ *	0.443	0.136	-2.65	0.008	(0.243, 0.809)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes**	0.610	0.085	-3.53	<0.001	(0.464, 0.803)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10	0.876	0.268	-0.43	0.666	(0.482, 1.594)
	11-15	0.970	0.239	-0.12	0.901	(0.598, 1.572)
	15 and above*	1.542	0.288	2.32	0.020	(1.069, 2.224)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	0.877	0.233	-0.49	0.621	(0.521, 1.475)
	Highly Concentrated	1.033	0.211	0.16	0.875	(0.691, 1.543)
	Monopoly	0.987	0.201	-0.06	0.949	(0.662, 1.472)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Fully implemented in all units, Implemented in one unit, partially implemented in one unit, and have resources to start implementing next year (FSHR), 1= No resources but considering implementation (NRCI)

***** $p < 0.05$

** $p < 0.001$

NA-Not Applicable, Comparison Group

Table 3.6 are the results from the univariate logistic regression of those hospitals that met all three RWA preconditions compared to those hospitals that are ready and willing but unable to implement due to lack of resources. Similar to the analysis reported in Table 3.4, all regions were less likely to be a NRCI than those in the NE and Mid-Atlantic region. Those with significantly less odds than the NE and Mid-Atlantic region are South Atlantic, West North Central, Pacific, and Mountain Region. Being part of a network decreased the odds of being a NRCI hospital when compared to not being part of a network. The odds are higher that the hospital would be a FSHR hospital when the facility is part of a network. The implementation of an EHR was also equating to lower

odds of being a NRCI compared to those with no EHR. However, having limited or no secure messaging or patient portal capabilities increased the odds of being a NRCI hospital. Those hospitals that had neither the capability to receive or send secure messages or provider portal data are 3.8 and 3.3 times, respectively, more likely than those hospitals that could do both to be a NRCI hospital.

In the comparison of primary services provided by the hospital, those with primary services of either psychiatric or specialty services were 4 times more likely to be a NRCI hospital compared to those with general primary services. Facilities with higher total bed counts had lower odds of being a NRCI, compared to those with 24 or less beds. Teaching hospitals were also less likely to be NRCI hospitals compared to non-teaching. However, those in the highest average HPSA score range were 1.5 times more likely to be a NRCI than those with no HPSA score.

Table 3.7: Telehealth Multivariate Analysis of Independent Multilevel Covariates (Hospitals that have resources to implement or have implemented compared to hospitals with interest but no resources) (n=1,920)

Independent Variable	**Independent Category**	**Odds Ratio**	**Robust Std Error**	**z**	***p*>|z|**	**95% Confidence Interval**
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.966	0.298	-0.11	0.909	(0.527, 1.767)
	All three forms are required	1.060	0.216	0.29	0.774	(0.711, 1.579)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.856	0.452	-0.29	0.769	(0.305, 2.408)
	All three forms are required	0.667	0.384	-0.70	0.482	(0.216, 2.059)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA

	Rural/Micro*	0.614	0.131	-2.29	0.022	(0.405, 0.932)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes*	1.650	0.311	2.66	0.008	(1.141, 2.388)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	1.344	0.267	1.49	0.137	(0.910, 1.984)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.726	0.191	-1.220	0.223	(0.434, 1.215)
	101-105	1.069	0.301	0.240	0.814	(0.615, 1.856)
	106-110	1.330	0.345	1.100	0.271	(0.800, 2.210)
	111-115	0.995	0.268	-0.020	0.985	(0.587, 1.688)
	>115	1.227	0.339	0.740	0.459	(0.714, 2.107)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic**	0.221	0.067	-4.980	<0.001	(0.122, 0.400)
	East North Central	0.731	0.194	-1.180	0.238	(0.434, 1.231)
	East South Central *	0.347	0.134	-2.730	0.006	(0.162, 0.741)
	West North Central *	0.422	0.132	-2.760	0.006	(0.229, 0.779)
	West South Central **	0.287	0.091	-3.960	<0.001	(0.155, 0.533)
	Mountain **	0.234	0.096	-3.530	<0.001	(0.104, 0.523)
	Pacific **	0.241	0.098	-3.520	<0.001	(0.109, 0.533)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes *	0.640	0.104	-2.74	0.006	(0.465, 0.881)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially *	0.541	0.117	-2.84	0.004	(0.355, 0.827)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only	1.213	0.234	1.00	0.316	(0.831, 1.770)
	Neither **	1.967	0.402	3.31	0.001	(1.317, 2.937)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only	1.590	0.356	2.07	0.038	(1.025, 2.467)
	Neither **	1.965	0.409	3.25	0.001	(1.307, 2.955)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit *	0.595	0.114	-2.72	0.007	(0.409, 0.865)
	Investor-owned, for-profit	0.653	0.147	-1.60	0.111	(0.387, 1.102)
Primary Service Provided						

	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled	1.566	0.503	1.40	0.163	(0.834, 2.940)
	Specialty *	2.481	0.742	3.04	0.002	(1.381, 4.457)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes	0.812	0.337	-0.50	0.616	(0.360, 1.831)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	1.034	0.296	0.120	0.906	(0.590, 1.814)
	50-99	0.921	0.283	-0.270	0.790	(0.504, 1.684)
	100-199	0.613	0.194	-1.550	0.121	(0.329, 1.139)
	200-299	0.938	0.336	-0.180	0.858	(0.465, 1.892)
	300-399	0.789	0.329	-0.570	0.570	(0.348, 1.788)
	400≤	0.699	0.276	-0.910	0.364	(0.323, 1.514)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes	0.743	0.138	-1.59	0.111	(0.516, 1.071)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10	0.756	0.265	-0.80	0.426	(0.380, 1.504)
	11-15	0.813	0.243	-0.69	0.489	(0.452, 1.462)
	15 and above *	1.758	0.430	2.31	0.021	(1.088, 2.840)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	0.965	0.299	-0.12	0.908	(0.526, 1.770)
	Highly Concentrated	1.052	0.264	0.20	0.810	(0.643, 1.720)
	Monopoly	1.285	0.372	0.86	0.387	(0.728, 2.268)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Fully implemented in all units, Implemented in one unit, partially implemented in one unit, and have resources to start implementing next year (FSHR), 1= No resources but considering implementation (NRCI)

***** $p < 0.05$

** $p < 0.001$

NA-Not Applicable, Comparison Group

Table 3.7 shows the results from the multivariate logistic regression where the dependent variable was split between those with no resources, but considering implementation and hospitals that had implemented, started implementing, or had resources to implement. Hospitals located in rural and micropolitan statistical areas had lower odds of being a NRCI hospital than those in urban areas. If the state the hospital was located in required additional consent from the patient the odds of being a NRCI

hospital were 65% more than those hospitals in states that did not require additional consent. All census divisions had lower odds of being a NRCI compared to the NE and Mid-Atlantic region. Those that had statistically significant lower odds of being a NRCI hospital were located in the East South Central, West North Central, West South Central, Pacific, and Mountain regions.

The odds of being a NRCI hospital were 36% lower for those hospitals in a network compared to those not in a network. Having an implemented EHR also lowered the odds of being a NRCI hospital. Having neither the capability to send nor receive secure messages or data through a provider portal nearly doubled the odds of being a NRCI when compared to hospitals with both capabilities. Hospitals with primary service categorized as specialty have 2.48 times greater odds of being a NRCI than those who were general service providers. The comparison group for hospital control were non-profit government hospitals. Non-profit, non-government and investor, for-profit organizations both had lower odds of being a NRCI hospital; however, the non-profit, non-government odds ratio was the only organizational control model that was statistically significant. Facilities located in the highest HPSA average score areas were 1.8 times more likely to be a NRCI, than those with no HPSA average score.

Table 3.8: Ordered Logistic Regression of Hospital Telehealth Implementation Levels (n=2,213)

Independent Variable	**Independent Category**	**Odds Ratio**	**Robust Std Error**	**z**	***p*>|z|**	**95% Confidence Interval**
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.825	0.193	-0.82	0.410	(0.521, 1.305)

	All three forms are required	0.823	0.136	-1.18	0.239	(0.594, 1.139)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	1.625	0.646	1.22	0.222	(0.746, 3.544)
	All three forms are required *	2.681	1.203	2.20	0.028	(1.113, 6.460)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro*	1.415	0.216	2.28	0.023	(1.050, 1.908)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes**	0.559	0.079	-4.13	<0.001	(0.424, 0.736)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	0.904	0.145	-0.63	0.529	(0.661, 1.237)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	1.220	0.236	1.03	0.304	(0.835, 1.783)
	101-105	0.964	0.209	-0.17	0.866	(0.631, 1.473)
	106-110	0.774	0.155	-1.28	0.199	(0.523, 1.145)
	111-115	0.874	0.181	-0.65	0.515	(0.583, 1.311)
	>115	0.748	0.163	-1.33	0.185	(0.488, 1.148)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic**	2.833	0.673	4.38	<0.001	(1.778, 4.515)
	East North Central	1.231	0.271	0.94	0.345	(0.800, 1.895)
	East South Central *	1.957	0.593	2.22	0.027	(1.081, 3.543)
	West North Central *	1.657	0.415	2.01	0.044	(1.013, 2.708)
	West South Central **	3.181	0.801	4.59	<0.001	(1.942, 5.212)
	Mountain *	2.282	0.725	2.60	0.009	(1.224, 4.255)
	Pacific **	3.007	0.924	3.58	<0.001	(1.647, 5.491)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes**	1.647	0.211	3.90	<0.001	(1.282, 2.117)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially	1.340	0.225	1.74	0.082	(0.963, 1.863)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only	0.853	0.129	-1.06	0.291	(0.634, 1.146)
	Neither *	0.699	0.106	-2.37	0.018	(0.520, 0.940)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA

	Send only or Receive only *	0.573	0.109	-2.92	0.003	(0.394, 0.832)
	Neither **	0.291	0.048	-7.56	<0.001	(0.211, 0.401)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit **	1.911	0.273	4.52	<0.001	(1.444, 2.531)
	Investor-owned, for-profit	0.952	0.176	-0.26	0.791	(0.662, 1.369)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled *	0.568	0.129	-2.50	0.013	(0.364, 0.886)
	Specialty **	0.197	0.40	-8.00	<0.001	(0.132, 0.293)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes	0.706	0.203	-1.21	0.226	(0.402, 1.240)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	0.943	0.211	-0.26	0.792	(0.608, 1.462)
	50-99	0.722	0.162	-1.42	0.155	(0.461, 1.131)
	100-199	1.195	0.288	0.74	0.461	(0.745, 1.916)
	200-299	1.093	0.305	0.32	0.749	(0.633, 1.888)
	300-399	1.161	0.366	0.47	0.635	(0.626, 2.154)
	400≤	1.494	0.453	1.33	0.185	(0.825, 2.705)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes	1.162	0.166	1.05	0.294	(0.878, 1.536)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10*	0.546	0.125	-2.64	0.008	(0.349, 0.856)
	11-15	1.26	0.288	1.00	0.315	(0.804, 1.969)
	15 and above	0.766	0.149	-1.37	0.172	(0.523, 1.122)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	1.018	0.235	0.08	0.939	(0.647, 1.599)
	Highly Concentrated	0.882	0.169	-0.66	0.512	(0.605, 1.284)
	Monopoly	0.768	0.171	-1.49	0.235	(0.496, 1.188)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Not in place and not considering implementing, 1 = Do not have the resources but contemplating implementing, 2= Fully implemented in all units, fully implemented in one unit, started implementing in one unit, have the resources to start implementing next year

***** $p < 0.05$

** $p < 0.001$

NA-Not Applicable, Comparison Group

Table 3.8 contains the results of an ordered logistic regression. This method is used as a sensitivity analysis. The odds of being a facility that has at least met 2 of the 3 conditions (readiness and willingness) are higher in states that require Medicaid to cover all three forms of telehealth technology. In the context of this logistic regression, it means that the odds of being a NRCI or FSHR are 2.7 times greater for states requiring Medicaid payment for all three technology types compared to NPNC hospitals, this is the same odds for FSHR when compared to NRCI and NPNC facilities when all other variables are held constant. Increased odds of being a NRCI or FSHR organization are 1.4 times higher in rural and micropolitan areas. Most of the statistically significant odds ratios shown in Table 3.8 are consistent with those found in both multivariate logistic regressions results in Tables 3.5 and 3.7.

Table 3.9: Telehealth Comparison of Logistic Regression Models for Significantly Associated Independent Variables

Independent Variable	Independent Category	Univariate Table 3.4	Multi Table 3.5	Univariate Table 3.6	Multi Table 3.7	Ordered Table 3.8
Medicaid Insurance						
	No Medicaid payer requirements					
	At least one form of telehealth is required					
	All three forms are required		M(X)			X
Metro/Rural						
	Metro					
	Rural/Micro				O	X
Patient Consent Required						
	No					
	Yes	O			X	O
Physician Required to have state license						
	No					
	Yes			X		

Census Division						
	NE &Mid-Atlantic					
	South Atlantic	O	M(O)	O		X
	East North Central					
	East South Central				O	X
	West North Central		O	O	O	X
	West South Central	O			O	X
	Mountain			O	O	X
	Pacific			O	O	X
Part of a Network						
	No					
	Yes	X		O	O	
Has an EHR						
	No					
	Fully or partially			O	O	
Secure Messaging Capabilities						
	Both					
	Send only or Receive Only			X		
	Neither			X	X	O
Provider Portal Capabilities						
	Both					
	Send only or Receive only			X		O
	Neither	O	O	X	X	O
Organization Control						
	Government, non-federal and Federal					
	Non-government, non-profit			O	O	X
	Investor-owned, for-profit	O				
Primary Service Provided						
	General					
	Psychiatric/Disabled	O		X		O
	Specialty	O	O	X	X	O
Physician Ownership						
	No					
	Yes	O				
Total Beds						
	0-24					
	25-49					

	50-99					
	100-199					
	200-299					
	300-399			O		
	400≤			O		
Teaching Hospital/Academic Center						
	No					
	Yes			O		
HPSA Average Score						
	0					
	1-10	O	O			O
	11-15					
	15 and above	X		X	X	
HHI Categories						
	Competitive					
	Moderately Concentrated					
	Highly Concentrated					
	Monopoly	M(X)				

O: Decreased Odds; X: Increased Odds; M(O): Marginally Decreased Odds; M(X): Marginally Increased Odds

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Table 3.9 is a comparison of all 5 logistic regression models for statistically significant variables. With the univariate and multivariate analysis for coinciding dependent variable groupings being placed near each other for comparison. The associations from the above table include the technology capabilities of a provider portal for a hospital. When the dependent variable was grouped as hospitals not considering implementing (NPNC) and hospitals with no resources but considering implementation, a lack of provider portal capabilities decreased the odds of being a NRCI facility. However, when the dependent variable was those hospitals that had implemented or were ready to implement (FSHR) and NRCI hospitals, the odds of being an NRCI hospital was greater when provider portal capabilities were low. This relates to the level of technology

capabilities already in the infrastructure. Those with implemented telehealth had more capabilities than those with no resources, however, those with no resources had more capabilities than those not considering implementing at all.

A similar juxtaposition in odds ratio can be seen in hospitals that report a specialty as their primary service. The odds are higher of being a NRCI hospital for reported specialty service providers when the dependent variable is FSHR hospitals and NRCI hospitals. The inverse is true when the dependent variable is NRCI and NPNC hospitals; the odds are less likely of being a NRCI hospital for specialty primary service hospitals. This would make sense as specialty clinics may not have the capacity to invest in telehealth technology, often being smaller. Specialty hospitals may also see less of an advantage to the use of telehealth compared to general primary service hospitals which may lack specialists in certain fields.

Remote Patient Monitoring Results

Table 3.10 contains the descriptive statistics of each independent variable category in relation to the dependent variable, RPM level of implementation.

Table 3.10: Multilevel Variables Tabulation and Chi-square for RPM (N=2,181)

Independent Variable	**Independent Category**	Fully implemented across all units (n=392)	Fully implemented in at least one unit (n=505)	Beginning to implement in at least one unit (n=191)	Have resources to implement in the next year (n=183)	Do not have resources but considering it (n=406)	Not in place and not considering implementation (n=504)	Pearson $\chi 2$
Private Insurance								26.14*
	No private payer requirements	147	186	79	45	135	158	

	At least one form of telehealth is required	44	78	25	36	76	74	
	All three forms are required	201	241	87	102	195	272	
Medicaid Insurance								20.18*
	No Medicaid payer requirements	6	12	8	5	7	7	
	At least one form of telehealth is required	298	398	164	143	330	407	
	All three forms are required	88	95	19	35	69	90	
Metro/Rural								22.03**
	Metro	270	364	145	126	264	308	
	Rural/Micro	122	141	46	57	142	196	
Patient Consent Required								43.76**
	No	224	335	97	78	216	256	
	Yes	168	170	94	105	190	248	
Physician Required to have state license								8.46
	No	277	366	146	145	314	378	
	Yes	115	139	45	38	92	126	
Area Deprivation Index Categorized								50.95*
	≤ 90	56	96	39	32	61	67	
	91-100	79	104	44	25	64	74	
	101-105	48	70	14	25	63	61	
	106-110	65	79	43	45	83	113	
	111-115	88	93	38	3	79	112	
	>115	56	63	13	24	56	77	
Census Division								134.58**
	NE &Mid-Atlantic	34	67	25	23	66	76	
	South Atlantic	78	104	34	21	37	65	
	East North Central	71	102	20	22	84	71	
	East South Central	33	20	8	9	23	42	
	West North Central	69	54	34	28	49	83	
	West South Central	55	57	39	49	72	103	

	Mountain	24	29	9	9	34	26	
	Pacific	28	72	12	22	41	38	
Part of a Network								73.88**
	No	204	234	105	106	250	360	
	Yes	188	271	86	77	156	144	
Has an EHR								81.12**
	No	28	37	26	24	63	123	
	Fully or partially	364	468	165	159	343	381	
Secure Messaging Capabilities								214.06**
	Both	288	319	137	125	185	187	
	Send only or Receive Only	62	112	33	29	100	123	
	Neither	42	74	21	29	151	194	
Provider Portal Capabilities								381.62**
	Both	172	208	127	61	75	61	
	Send only or Receive only	92	143	25	53	96	76	
	Neither	128	154	39	69	235	367	
Organization Control								271.80**
	Government, non-federal and Federal	75	87	24	37	106	156	
	Non-government, non-profit	284	380	91	127	250	197	
	Investor-owned, for-profit	33	38	76	19	50	151	
Primary Service Provided								313.45**
	General	373	484	181	161	349	314	
	Psychiatric/Disabled	4	4	3	6	28	88	
	Specialty	15	17	7	16	29	102	
Physician Ownership								13.15*
	No	386	488	182	175	393	474	
	Yes	6	17	9	8	13	30	
Total Beds								169.66**
	0-24	40	26	9	23	37	50	
	25-49	47	78	27	40	84	141	
	50-99	59	75	26	30	76	131	
	100-199	83	125	42	32	99	97	
	200-299	54	65	35	22	47	39	
	300-399	44	45	25	14	27	23	
	400≤	65	91	27	22	36	23	

Teaching Hospital/Academic Center								58.84**
	No	206	248	97	102	251	354	
	Yes	186	257	94	81	155	150	
HPSA Average Score								34.58*
	0	295	375	152	138	273	356	
	1-10	25	26	8	12	31	48	
	11-15	34	30	16	16	40	51	
	15 and above	38	74	15	17	62	49	
HHI Categories								31.14*
	Competitive	23	37	26	26	37	43	
	Moderately Concentrated	37	37	21	12	23	30	
	Highly Concentrated	146	176	63	54	137	188	
	Monopoly	186	255	81	91	209	243	

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index
***** $p < 0.05$
** $p < 0.001$

To better understand the association of multilevel CSTS factors on the level of implementation particularly in relation to those hospitals considering implementation but not having the resources, two binary dependent variables were created. The first analysis was done with the binary dependent variable of hospitals that do not have RPM in place and are not considering implementing RPM, and those that are considering implementing RPM but don't have resources. The results of the univariate logistic regression are shown in Table 3.11. The factors associated with increased odds of being a NRCI compared to a NPNC are fewer than those in the telehealth univariate logistic regression. Similar to the telehealth univariate analysis when hospitals are NPNC and NRCI, having no provider portal capabilities decrease the odds of being a NRCI hospital. Being a hospital with primary services other than general also greatly decreased the odds of being a NRCI hospital. Many of the factors that are associated in this RPM univariate analysis were also

associated in the telehealth univariate analysis comparing NPNC and NRCI for multilevel factors.

Table 3.11: RPM Univariate Analysis of Independent Multilevel Covariates (Hospitals not considering implementation compared to hospitals considering but no resources) (n=910)

Independent Variable	Independent Category	Odds Ratio	Robust Std Error	z	*p*>|z|	95% Confidence Interval
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	1.202	0.241	0.91	0.360	(0.810, 1.783)
	All three forms are required	0.839	0.126	-1.17	0.243	(0.625, 1.126)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.811	0.438	-0.39	0.698	(0.581, 2.336)
	All three forms are required	0.767	0.428	-0.48	0.634	(0.257, 2.290)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro	0.845	0.117	-1.21	0.225	(0.644, 1.109)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes	0.908	0.121	-0.72	0.470	(0.699, 1.180)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	0.879	0.138	-0.82	0.411	(0.646, 1.196)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.950	0.234	-0.21	0.835	(0.587, 1.539)
	101-105	1.134	0.286	0.50	0.617	(0.692, 1.860)
	106-110	0.807	0.184	-0.94	0.515	(0.515, 1.263)
	111-115	0.775	0.178	-1.11	0.493	(0.493, 1.216)
	>115	0.799	0.199	-0.90	0.490	(0.490, 1.303)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic	0.655	0.174	-1.59	0.112	(0.389, 1.104)
	East North Central	1.362	0.318	1.33	0.185	(0.863, 2.152)
	East South Central	0.631	0.195	-1.49	0.136	(0.344, 1.156)
	West North Central	0.680	0.1677	-1.56	0.118	(0.419, 1.102)

	West South Central	0.805	0.183	-0.95	0.341	(0.515, 1.258)
	Mountain	1.506	0.467	1.32	0.187	(0.820, 2.766)
	Pacific	1.242	0.349	0.77	0.440	(0.716, 2.156)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes*	1.56	0.221	3.13	0.002	(1.181, 2.060)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially**	1.758	0.302	3.28	0.001	(1.255, 2.462)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only	0.822	0.140	-1.15	0.248	(0.589, 1.147)
	Neither *	0.630	0.098	-2.97	0.003	(0.465, 0.855)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only	1.027	0.237	0.12	0.907	(0.653, 1.616)
	Neither**	0.521	0.010	-3.40	0.001	(0.358, 0.758)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit **	1.868	0.295	3.95	<0.001	(1.370, 2.545)
	Investor-owned, for-profit **	0.487	0.100	-3.49	<0.001	(0.325, 0.730)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled **	0.286	0.066	-5.42	<0.001	(0.182, 0.450)
	Specialty **	0.256	0.057	-6.07	<0.001	(0.165, 0.397)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes†	0.523	0.177	-1.91	0.056	(0.269, 1.016)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	0.805	0.207	-0.84	0.399	(0.486, 1.332)
	50-99	0.784	0.204	-0.93	0.350	(0.470, 1.306)
	100-199	1.379	0.358	1.24	0.216	(0.829, 2.295)
	200-299	1.629	0.499	1.59	0.112	(0.893, 2.971)
	300-399	1.586	0.567	1.29	0.197	(0.787, 3.196)
	400≤ *	2.115	0.728	2.18	0.029	(1.078, 4.152)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes*	1.457	0.206	2.67	0.008	(1.105, 1.922)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10	0.842	0.206	-0.70	0.482	(0.522, 1.359)
	11-15	1.023	0.231	0.10	0.921	(0.657, 1.593)

	15 and above*	1.650	0.352	2.41	0.016	(1.098, 2.478)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	1.127	0.294	0.46	0.646	(0.677, 1.878)
	Highly Concentrated	0.903	0.184	-0.50	0.615	(0.606, 1.346)
	Monopoly	0.960	0.197	-0.20	0.843	(0.642, 1.436)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index
Dependent Variable: 0 = Not in place and not considering implementation (NPNC), 1= No resources but considering implementation (NRCI)
***** $p < 0.05$
** $p < 0.001$
†Marginally significant (0.051-0.060)
NA-Not Applicable, Comparison Group

Table 3.12 contains the results of the multivariate logistic regression of NRCI and NPNC hospitals. The odds of being a NRCI decreased as the requirements for private insurance reimbursement increased. The more types of technology that were required to be reimbursed the less likely the odds of being a NRCI. This may be more significant than in the general telehealth analysis because of the decreased number of states that require private payers to reimburse for RPM. The odds of being a NRCI increase approximately 50% for hospitals that are non-government, non-profit in organizational control, however, the odds decrease by 50% for hospitals that are investor-owned, for-profit. This would likely relate back to available funds, and the market edge that may be needed by a for-profit hospital compared to a non-profit. Psychiatric and specialty primary service providers had odds of approximately 80% and 70% lower than general primary service of being a NRCI.

Table 3.12: RPM Multivariate Analysis of Independent Multilevel Covariates (Hospitals with no interest compared to hospitals with interest but no resources) (n=910)

Independent Variable	**Independent Category**	**Odds Ratio**	**Robust Std Error**	**z**	***p*>|z|**	**95% Confidence Interval**
Private Insurance						

	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required *	0.520	0.167	-2.04	0.041	(0.277, 0.974)
	All three forms are required *	0.563	0.129	-2.50	0.012	(0.359, 0.883)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	1.366	0.801	0.53	0.594	(0.433, 4.311)
	All three forms are required	2.005	1.319	1.06	0.290	(0.552, 7.281)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro	0.707	0.146	-1.68	0.093	(0.472, 1.060)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes	1.280	0.237	1.33	0.182	(0.891, 1.840)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	0.893	0.192	-0.53	0.598	(0.585, 1.361)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.700	0.196	-1.28	0.202	(0.404, 1.210)
	101-105	1.019	0.304	0.06	0.949	(0.569, 1.827)
	106-110	0.717	0.205	-1.16	0.245	(0.409, 1.256)
	111-115	0.639	0.191	-1.49	0.135	(0.356, 1.150)
	>115	0.594	0.182	-1.70	0.089	(0.325, 1.084)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic	0.676	0.227	-1.16	0.245	(0.350, 1.307)
	East North Central	1.336	0.377	1.03	0.305	(0.768, 2.322)
	East South Central	0.745	0.311	-0.70	0.481	(0.329, 1.689)
	West North Central	0.578	0.204	-1.55	0.121	(0.289, 1.155)
	West South Central	1.634	0.512	1.57	0.117	(0.885, 3.018)
	Mountain	1.730	0.713	1.33	0.184	(0.771, 3.882)
	Pacific	1.247	0.506	0.54	0.586	(0.563, 2.762)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes	1.215	0.201	1.17	0.241	(0.878, 1.681)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially	0.909	0.199	-0.44	0.661	(0.592, 1.396)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only	0.706	0.139	-1.77	0.077	(0.481, 1.038)

	Neither	1.121	0.220	0.58	0.559	(0.764, 1.646)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only	1.174	0.326	0.58	0.563	(0.681, 2.023)
	Neither	0.773	0.174	-1.14	0.253	(0.496, 1.203)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit *	1.498	0.280	2.16	0.031	(1.038, 2.162)
	Investor-owned, for-profit *	0.572	0.158	-2.03	0.043	(0.333, 0.981)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled **	0.231	0.072	-4.73	<0.001	(0.126, 0.424)
	Specialty **	0.300	0.097	-3.74	<0.001	(0.160, 0.564)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes	0.803	0.322	-0.55	0.585	(0.365, 1.764)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	0.783	0.233	-0.82	0.411	(0.436, 1.404)
	50-99	0.882	0.278	-0.40	0.690	(0.475, 1.637)
	100-199	1.340	0.438	0.80	0.370	(0.707, 2.543)
	200-299	1.156	0.454	0.37	0.711	(0.536, 2.496)
	300-399	0.978	0.436	-0.05	0.960	(0.408, 2.345)
	400≤	1.169	0.516	0.35	0.723	(0.492, 2.779)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes	0.792	0.156	-1.18	0.236	(0.539, 1.164)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10	0.749	0.222	-0.97	0.330	(0.418, 1.340)
	11-15	0.849	0.541	-0.58	0.565	(0.487, 1.482)
	15 and above	1.487	0.390	1.51	0.130	(0.889, 2.486)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	1.264	0.378	0.78	0.434	(0.703, 2.270)
	Highly Concentrated	0.970	0.242	-0.12	0.902	(0.595, 1.580)
	Monopoly	0.763	0.219	-0.94	0.346	(0.435, 1.338)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Not in place and not considering implementation (NPNC), 1= No resources but considering implementation (NRCI)

***** $p < 0.05$

** $p < 0.001$

NA-Not Applicable, Comparison Group

Table 3.13: RPM Univariate Analysis of Independent Multilevel Covariates (Hospitals that have resources to implement or have implemented compared to hospitals considering implementation with no resources) (n=1,677)

Independent Variable	Independent Category	Odds Ratio	Robust Std Error	z	*p*>|z|	95% Confidence Interval
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required *	1.406	0.236	2.03	0.043	(1.011, 1.954)
	All three forms are required	1.046	0.134	0.35	0.724	(0.814, 1.344)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	1.457	0.617	0.89	0.374	(0.635, 3.341)
	All three forms are required	1.289	0.568	0.58	0.564	(0.544, 0.057)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro *	1.330	0.161	2.35	0.019	(1.049, 1.686)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes	1.202	0.138	1.61	0.108	(0.961, 1.505)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	0.812	0.109	-1.55	0.122	(0.624, 1.057)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.928	0.187	-0.37	0.712	(0.626, 1.377)
	101-105	1.467	0.305	1.84	0.065	(0.976, 2.204)
	106-110	1.308	0.252	1.39	0.164	(0.896, 1.909)
	111-115	1.151	0.223	0.72	0.469	(0.787, 1.682)
	>115	1.312	0.279	1.28	0.201	(0.865, 1.990)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic **	0.352	0.081	-4.52	<0.001	(0.224, 0.554)
	East North Central	0.882	0.173	-0.64	0.522	(0.601, 1.295)
	East South Central	0.742	0.209	-1.06	0.290	(0.427, 1.290)
	West North Central *	0.598	0.131	-2.35	0.019	(0.390, 0.917)
	West South Central	0.813	0.164	-1.03	0.304	(0.547, 1.207)
	Mountain	0.948	0.239	-0.21	0.831	(0.578, 1.554)
	Pacific	0.691	0.160	-1.60	0.111	(0.439, 1.088)
Part of a Network						
	No	NA	NA	NA	NA	NA

	Yes **	0.651	0.076	-3.68	<0.001	(0.518, 0.818)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially **	0.542	0.091	-3.64	<0.001	(0.389, 0.753)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only **	1.990	0.287	4.77	<0.001	(1.500, 2.640)
	Neither **	3.423	0.494	8.52	<0.001	(2.580, 4.544)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only **	2.323	0.394	4.97	<0.001	(1.666, 3.238)
	Neither **	4.563	0.676	10.25	<0.001	(3.414, 6.100)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit **	0.596	0.082	-3.74	<0.001	(0.455, 0.782)
	Investor-owned, for-profit *	0.634	0.127	-2.28	0.022	(0.428, 0.938)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled**	5.659	1.774	5.53	<0.001	(3.061, 10.461)
	Specialty **	1.811	0.430	2.50	0.012	(1.137, 2.885)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes	1.018	0.330	0.05	0.956	(0.539, 1.923)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	1.159	0.270	0.63	0.527	(0.734, 1.830)
	50-99	1.095	0.250	0.24	0.807	(0.667, 1.682)
	100-199	0.930	0.210	-0.32	0.747	(0.598, 1.447)
	200-299	0.707	0.179	-1.37	0.172	(0.430, 1.162)
	300-399 *	0.559	0.160	-2.03	0.042	(0.319, 0.980)
	400≤ *	0.465	0.123	-2.89	0.004	(0.277, 0.781)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes**	0.653	0.076	-3.66	<0.001	(0.519, 0.820)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10 †	1.535	0.347	1.90	0.058	(0.986, 2.391)
	11-15 †	1.465	0.294	1.91	0.057	(0.989, 2.170)
	15 and above*	1.514	0.252	2.49	0.013	(1.092, 2.099)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	1.052	0.229	0.23	0.815	(0.687, 1.612)
	Highly Concentrated	1.047	0.182	0.27	0.790	(0.745, 1.472)

	Monopoly	0.978	0.170	-0.13	0.897	(0.695, 0.1375)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index
Dependent Variable: 0 = Fully implemented in all units, Implemented in one unit, partially implemented in one unit, and have resources to start implementing next year (FSHR), 1= No resources but considering implementation (NRCI)
***** $p < 0.05$
** $p < 0.001$
†Marginally significant (0.051-0.060)
NA-Not Applicable, Comparison Group

The univariate analysis of the binary outcome of hospitals that had implemented fully or partially, had started to implement or had resources to implement in the future compared to those hospitals with no resources by multilevel factors is reported in Table 3.13. State policy that required telehealth providers to gain additional consent from patients increased the odds of being a NRCI facility. Having no secure messaging or provider portal capabilities increased the odds of being a NRCI hospital compared to those that had greater capabilities, such as two-way communication.

Table 3.14: RPM Multivariate Analysis of Independent Multilevel Covariates (Hospitals that have resources to implement or have implemented compared to hospitals with interest but no resources) (n=1,677)

Independent Variable	**Independent Category**	**Odds Ratio**	**Robust Std Error**	**z**	***p*>|z|**	**95% Confidence Interval**
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	1.485	0.407	1.44	0.149	(0.768, 2.543)
	All three forms are required	0.836	0.158	-0.94	0.346	(0.578, 1.212)
Medicaid Insurance						
	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	1.345	0.650	0.61	0.539	(0.522, 3.467)
	All three forms are required	1.386	0.747	0.61	0.545	(0.482, 3.986)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro	0.920	0.165	-0.46	0.642	(0.647, 1.308)

Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes**	1.789	0.289	3.60	<0.001	(1.304, 2.455)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	0.807	0.147	-1.18	0.238	(0.565, 1.152)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.892	0.199	-0.51	0.608	(0.576, 1.381)
	101-105	1.411	0.323	1.50	0.133	(0.901, 2.209)
	106-110	1.188	0.269	0.76	0.448	(0.762, 1.852)
	111-115	1.084	0.257	0.34	0.734	(0.681, 1.727)
	>115	1.239	0.315	0.84	0.398	(0.753, 2.039)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic **	0.277	0.077	-4.65	<0.001	(0.162, 0.476)
	East North Central	0.849	0.210	-0.66	0.508	(0.522, 1.380)
	East South Central *	0.298	0.112	-3.22	0.001	(0.142, 0.623)
	West North Central *	0.305	0.088	-4.13	<0.001	(0.174, 0.536)
	West South Central *	0.479	0.134	-2.62	0.009	(0.276, 0.831)
	Mountain *	0.499	0.164	-2.12	0.034	(0.263, 0.949)
	Pacific **	0.283	0.104	-3.44	0.001	(0.138, 0.581)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes	0.836	0.114	-1.32	0.188	(0.641, 1.091)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially	0.820	0.174	-0.93	0.351	(0.540, 1.244)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only	1.325	0.217	1.72	0.085	(0.962, 1.826)
	Neither *	1.576	0.280	2.56	0.010	(1.113, 2.232)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only **	2.017	0.369	3.84	<0.001	(1.409, 2.888)
	Neither **	3.414	0.601	6.97	<0.001	(2.417, 4.821)
Organization Control						
	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit †	0.717	0.123	-1.94	0.053	(0.512, 1.004)
	Investor-owned, for-profit *	0.487	0.122	-2.86	0.004	(0.297, 0.797)
Primary Service Provided						
	General	NA	NA	NA	NA	NA

	Psychiatric/Disabled *	2.87	1.098	2.77	0.006	(1.361, 6.076)
	Specialty	1.436	0.405	1.28	0.199	(0.827, 2.496)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes	0.760	0.269	-0.78	0.438	(0.380, 1.521)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49	1.347	0.347	1.16	0.248	(0.813, 2.233)
	50-99	1.230	0.333	0.77	0.444	(0.724, 2.090)
	100-199	1.289	0.350	0.93	0.350	(0.757, 2.196)
	200-299	1.050	0.320	0.16	0.872	(0.578, 1.908)
	300-399	0.863	0.300	-0.42	0.673	(0.437, 1.708)
	400≤	0.745	0.254	-0.87	0.387	(0.382, 1.452)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes	0.805	0.125	-1.40	0.160	(0.594, 1.090)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10	1.228	0.317	0.80	0.426	(0.741, 2.038)
	11-15	1.267	0.303	0.99	0.321	(0.794, 2.023)
	15 and above	1.316	0.283	1.28	0.202	(0.863, 2.007)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	1.006	0.247	0.03	0.979	(0.623, 1.627)
	Highly Concentrated	0.966	0.201	-0.17	0.866	(0.642, 1.452)
	Monopoly	0.937	0.221	-0.27	0.784	(0.590, 1.488)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Fully implemented in all units, Implemented in one unit, partially implemented in one unit, and have resources to start implementing next year (FSHR), 1= No resources but considering implementation (NRCI)

***** $p < 0.05$

** $p < 0.001$

†Marginally significant (0.051-0.060)

NA-Not Applicable, Comparison Group

Table 3.14 contains the results of the logistic regression for the binary outcome dependent variable. The barrier of obtaining patient consent was still statistically significant after holding all other variables constant. The odds of being a NRCI hospital were 80% higher than those states without this legal requirement. Other than the East North Central census division, all other regions were less likely to be a NRCI hospital than the NE and Mid-Atlantic census division. Like the univariate analysis, current technology capabilities significantly impacted the odds of being an NRCI. Particularly for

provider portal capabilities, those with no provider portal capabilities were 3.4 times more likely to be a NRCI hospital than those with two-way capabilities.

The ordered logistic regression analysis for the RPM implementation levels yielded similar results to those in the previous two multivariate logistic regressions (Table 3.16). The odds were lower for states requiring private insurance to reimburse for at least one form of telehealth, when those not considering implementing were compared to those who met at least the ready and willing preconditions. The odds were also lower for those who met all 3 preconditions when compared to hospitals who didn't meet at least 1 precondition, in the context of states requiring at least one form of telehealth technology to be reimbursed by private insurers. This analysis also found that the odds were lower of being a NRCI or FSHR when a hospital was located in an area that had the highest level of ADI score. This analysis also noted a change in odds ratio as hospitals grew in size in relation to total beds. The 3 levels just above the smallest hospital size (0-24 beds) had a decrease in odds of being either an NRCI or FSHR. However, as hospitals reached sizes of 200 or greater the odds increased, although not significantly at most levels.

Table 3.15: Ordered Logistic Regression of Hospital RPM Implementation Levels (n=2,181)

Independent Variable	**Independent Category**	**Odds Ratio**	**Robust Std Error**	**z**	***p*>|z|**	**95% Confidence Interval**
Private Insurance						
	No private payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required *	0.507	0.110	-3.12	0.002	(0.331, 0.777)
	All three forms are required	0.863	0.127	-1.00	0.316	(0.646, 1.151)
Medicaid Insurance						

	No Medicaid payer requirements	NA	NA	NA	NA	NA
	At least one form of telehealth is required	0.910	0.300	-0.29	0.775	(0.477, 1.736)
	All three forms are required	1.032	0.387	0.08	0.934	(0.495, 2.151)
Metro/Rural						
	Metro	NA	NA	NA	NA	NA
	Rural/Micro	0.860	0.113	-1.14	0.254	(0.664, 1.114)
Patient Consent Required						
	No	NA	NA	NA	NA	NA
	Yes*	0.717	0.085	-2.81	0.005	(0.568, 0.904)
Physician Required to have state license						
	No	NA	NA	NA	NA	NA
	Yes	1.155	0.153	1.09	0.278	(0.890, 1.498)
Area Deprivation Index Categorized						
	≤ 90	NA	NA	NA	NA	NA
	91-100	0.891	0.148	-0.69	0.488	(0.643, 1.235)
	101-105	0.756	0.132	-1.61	0.108	(0.537, 1.063)
	106-110	0.733	0.125	-1.82	0.069	(0.524, 1.024)
	111-115	0.726	0.127	-1.83	0.068	(0.514, 1.024)
	>115 *	0.613	0.117	-2.57	0.010	(0.422, 0.891)
Census Division						
	NE &Mid-Atlantic	NA	NA	NA	NA	NA
	South Atlantic**	2.429	0.516	4.18	<0.001	(1.602, 3.684)
	East North Central	1.337	0.254	1.53	0.127	(0.921, 1.940)
	East South Central *	2.143	0.623	2.62	0.009	(1.212, 3.788)
	West North Central *	2.012	0.452	3.11	0.002	(1.295, 3.126)
	West South Central **	2.493	0.522	4.36	<0.001	(1.653, 3.759)
	Mountain **	2.410	0.644	3.29	0.001	(1.428, 4.068)
	Pacific **	3.160	0.882	4.12	<0.001	(1.828, 5.461)
Part of a Network						
	No	NA	NA	NA	NA	NA
	Yes*	1.267	0.132	2.26	0.024	(1.032, 1.554)
Has an EHR						
	No	NA	NA	NA	NA	NA
	Fully or partially	1.084	0.170	0.52	0.605	(0.798, 1.474)
Secure Messaging Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive Only **	0.656	0.083	-3.33	0.001	(0.512, 0.841)
	Neither	0.808	0.105	-1.65	0.100	(0.626, 1.041)
Provider Portal Capabilities						
	Both	NA	NA	NA	NA	NA
	Send only or Receive only **	0.551	0.083	-3.94	<0.001	(0.410, 0741)
	Neither **	0.252	0.033	-10.51	<0.001	(0.195, 0.326)
Organization Control						

	Government, non-federal and Federal	NA	NA	NA	NA	NA
	Non-government, non-profit **	1.724	0.221	4.24	<0.001	(1.341, 2.217)
	Investor-owned, for-profit	1.161	0.206	0.84	0.401	(0.820, 1.643)
Primary Service Provided						
	General	NA	NA	NA	NA	NA
	Psychiatric/Disabled **	0.180	0.041	-7.46	<0.001	(0.115, 0.282)
	Specialty **	0.280	0.057	-6.27	<0.001	(0.188, 0.416)
Physician Ownership						
	No	NA	NA	NA	NA	NA
	Yes	1.204	0.303	0.74	0.460	(0.735, 1.973)
Total Beds						
	0-24	NA	NA	NA	NA	NA
	25-49 *	0.645	0.125	-2.26	0.024	(0.440, 0.944)
	50-99	0.747	0.151	-1.45	0.148	(0.502, 1.109)
	100-199	0.919	0.188	-0.41	0.678	(0.615, 1.372)
	200-299	1.076	0.255	0.31	0.758	(0.676, 1.712)
	300-399	1.157	0.313	0.54	0.590	(0.681, 1.966)
	400≤	1.474	0.390	1.46	0.143	(0.877, 2.477)
Teaching Hospital/Academic Center						
	No	NA	NA	NA	NA	NA
	Yes	1.036	0.123	0.30	0.766	(0.821, 1.307)
HPSA Average Score						
	0	NA	NA	NA	NA	NA
	1-10	0.739	0.139	-1.61	0.108	(0.511, 1.069)
	11-15	0.782	0.143	-1.35	0.177	(0.547, 1.118)
	15 and above	1.005	0.167	0.03	0.977	(0.725, 1.392)
HHI Categories						
	Competitive	NA	NA	NA	NA	NA
	Moderately Concentrated	1.150	0.212	0.76	0.448	(0.801, 1.652)
	Highly Concentrated	0.975	0.152	-0.16	0.870	(0.718, 1.323)
	Monopoly	0.883	0.156	-0.71	0.480	(0.625, 1.247)

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

Dependent Variable: 0 = Not in place and not considering implementing (NPNC), 1 = Do not have the resources but contemplating implementing (NRCI), 2= Fully implemented in all units, fully implemented in one unit, started implementing in one unit, have the resources to start implementing next year (FSHR)

***** $p < 0.05$

** $p < 0.001$

NA-Not Applicable, Comparison Group

Table 3.16 provides an overview of the different logistic regressions that were run for RPM implementation levels. Similar to the results in the comparison of telehealth models, having no provider portal capabilities significantly reduced the odds of being an

NRCI hospital when compared to NPNC but increased the odds when compared to FSHR hospitals. Also statistically significant was the decreased odds of being a NRCI when the hospital primarily provided psychiatric services or services for the disabled compared to general primary services in the NRCI and NPNC analyses. The odds ratio was reversed for the logistic regression analyses for comparison of NRCI and FSHR hospitals.

Table 3.16: RPM Comparison of Logistic Regression Models for Significantly Associated Independent Variables

Independent Variable	Independent Category	Univariate Table 3.11	Multi Table 3.12	Univariate Table 3.13	Multi Table 3.14	Ordered Table 3.15
Private Insurance						
	No Private payer requirements					
	At least one form of telehealth is required		O	X		O
	All three forms are required		O			
Metro/Rural						
	Metro					
	Rural/Micro			X		
Patient Consent Required						
	No					
	Yes				X	X
Area Deprivation Index Categorized						
	≤ 90					
	91-100					
	101-105					
	106-110					
	111-115					
	>115					O
Census Division						
	NE &Mid-Atlantic					
	South Atlantic			O	O	X
	East North Central					
	East South Central				O	X
	West North Central			O	O	X
	West South Central				O	X
	Mountain				O	X
	Pacific				O	X

Part of a Network						
	No					
	Yes	X		O		X
Has an EHR						
	No					
	Fully or partially	X		O		
Secure Messaging Capabilities						
	Both					
	Send only or Receive Only			X		O
	Neither	O		X	X	
Provider Portal Capabilities						
	Both					
	Send only or Receive only			X	X	O
	Neither	O		X	X	O
Organization Control						
	Government, non-federal and Federal					
	Non-government, non-profit	X	X	O	M(O)	X
	Investor-owned, for-profit	O	O	O	O	
Primary Service Provided						
	General					
	Psychiatric/Disabled	O	O	X	X	O
	Specialty	O	O	X		O
Physician Ownership						
	No					
	Yes	M(O)				
Total Beds						
	0-24					
	25-49					O
	50-99					
	100-199					
	200-299					
	300-399			O		
	400≤	X		O		
Teaching Hospital/Academic Center						
	No					
	Yes	X				

HPSA Average Score						
	0					
	1-10			M(X)		
	11-15			M(X)		
	15 and above	X		X		

O: Decreased Odds; X: Increased Odds; M(O): Marginally Decreased Odds; M(X): Marginally Increased Odds

EHR: Electronic Health Record; HPSA: Health Professional Shortage Area; HHI: Herfindahl-Hirschman index

IV. Discussion:

The aim of this study was to determine the multilevel factors that differed between hospitals that are ready and willing to implement either telehealth or RPM but do not have the resources compared to those that have met all three RWA preconditions or those that have not met the ready or willing preconditions. To complete this analysis, the hospitals were grouped by the RWA categorization. This allowed for multivariate logistic regression to compare the groups in relation to multi-level independent variables as defined in the RWA CSTS hybrid framework.

Along with multivariate logistic regression, ordered and univariate logistic regression was done and chi-square testing. By using multiple different forms of analysis to compare different categorizations of dependent variables we could alleviate any questionability related to the distribution of the data. Chi-square testing assumes a normal distribution, however, this was a fairly large sample of hospitals which could compensate for any skew in the data. To be safe, ordered logistic regression was done, which categorized the hospitals on the level of implementation. Ordered logistic regression assumes proportional odds between levels, sensitivity analysis earlier had determined that this was not the case, but the model was fit to the best ability with the given data.

However, this was not the main model of the analysis and was used primarily for sensitivity analysis. To evaluate the overall differences when all variables were included, the outcome variable of level of telehealth (RPM) implementation was separated into the outcome of interest (do not have resources, but are considering) in comparison to hospitals with no technology in place and not interested in implementing or the remaining hospitals who had, started, or were ready to implement technology. The combination of these three forms of testing encompassed the research question asked in slightly different ways.

One area that is of particular interest from this study is related to the system structure and operational processes with relation to the hospital's ability to implement telehealth and/or RPM. Within both analyses, there was an association between the abilities of the hospital's technology infrastructure and the level of adoption. Decreased functionality related to provider portal and secure messaging increased the odds of being a hospital with NRCI versus FSHR but decreased the odds of being a NRCI compared to NPNC. Based on these results it appears that hospitals that particularly lack any capability to securely message with providers or exchange data via a provider portal are unlikely to meet all three preconditions of implementation. Within the ordered logistic regression, the odds are cumulative and represent the odds when NPNC are compared to combined NRCI and FSHR and when NPNC and NRCI are compared to FSHR. Although not truly proportional, the odds ratio is negative and statistically significant.

Similar results were found for being a primary service provider of either psychiatric or specialty services compared to general services. General hospitals or primary care clinics may need to use telehealth more due to the lack of specialists

available in-house and the increasing need to coordinate chronic care conditions for their patients. [9,67,84,85] Univariate analysis for both RPM and telehealth and for each binary categorization of the outcome variable (NRCI/NPNC and NRCI/FSHR) yielded statistically significantly higher odds of being an NRCI hospital when located in the highest HPSA score areas. Due to the lack of providers in the area, the need would be increased, this lends to increased willingness and readiness to adopt technology. However, these areas are often remote and rural, so resources and technology capabilities may be too low to allow the ability to get the needed technology implemented. [40,76]

Patient consent was not statistically significant through all analyses, but the direction of association points toward the limiting ability this policy has on the implementation level. Within the telehealth analyses, the odds of being a NRCI hospital were lower when consent was required, when the outcome variable was categorized as NPNC and NRCI. The odds of being an NRCI hospital were higher when the dependent variable was FSHR and NRCI. The ordered logistic regression model was similar to the odds ratio results for technology capabilities, suggesting that this environmental level factor could limit the ability to reach all three preconditions of RWA. Organizational control was also statistically significant in both binary outcomes in the RPM analyses. Investor-owned for-profit were less likely in both binary categorizations of the outcome variable analyses to be a NRCI hospital. This leads to the conjecture that investor-owned for-profit organizations may have a more black and white reasoning system. They will either not be ready or willing, or they will be all in and meet all 3 conditions. The odds of being a facility that wants to implement but without resources is highly unlikely in

investor for-profit hospitals within this analysis when controlling for other multi-level factors.

Limitations:

The first limitation of this study to note is the data set itself. The analysis is limited to those hospitals contacted by the American Hospital Association and then responded to both the Annual Survey and the IT Supplement Survey. There is the potential that those who have more experience with health information technology (HIT) may have biased the results by responding more frequently to the IT supplement. Tabulation data for telehealth response showed that those that had implemented in all units made up about 21% of the respondents, and those without resources and those without interest or intent combined made up approximately 25%. The rest was distributed at the remaining three levels of implementation. Approximately 40% of the hospitals were not intending to implement or had no resources to implement RPM, with 18% fully implemented in all units. This is more likely due to the specialization of RPM and the additional cost it can have to monitor within a patient's home. The AHA survey's overall response rate averages approximately 80% each year. For those hospitals who do not respond, nine key variables are estimated through statistical methodology in comparison to previous year surveys to estimate the missing values in the current year of data.

This study must assume that this is similar to the makeup of hospitals in the US for this dataset.[78] The different analyses and categorization of variables sought to include as many hospitals as possible without having missing data. The current year's missing value is "predicted" by multiplying the base year data with the corresponding coefficients derived from the regression model. [78] This survey is sent to AHA member hospitals and

those outside membership, with the high response rate, estimation techniques and many years of surveying the results of a study using AHA data should be considered comparable to the actual US hospital distribution. [78]

A second limitation of the study is the lack of definition within the AHA IT supplement survey of the definition of telehealth or the technologies that are considered telehealth. There are also definitions lacking for secure messaging and patient portal, all of which are fairly new technology, although meaningful use is increasing the diffusion of these features related to EHR. To overcome the lack of definitions the use of multiple variables for a level and precondition were used. For technology ability, secure messaging, patient portal, and implemented EHR were used. This gave three related options of existing technology to study in relation to telehealth and RPM implementation. RPM is a specific form of telehealth so doing the double analysis allowed the confirmation of the telehealth results. RPM has a less broad definition compared to telehealth. Remote patient monitoring (RPM) uses "digital technologies to collect medical and other forms of health data from individuals in one location and electronically transmit that information securely to health care providers in a different location for assessment and recommendations."[86]

One limitation within the HPSA score variable that led to the logistic regression analysis showing a significance between the second lowest scoring (1-10) and the lowest scoring level (0) may be due to the large number of observations which are not designated as being in an HPSA area. This makes sense as the HPSA areas would have fewer providers and hospitals, but this could be the reason for the difference between these two levels in the telehealth analyses. However, this was not the case within RPM

most likely due to the difference in the distribution of hospitals between telehealth and RPM implementation in HPSA average score levels.

V. Conclusion

This study verifies the need for proper technology infrastructure at the system and operational level. There is a potential connection with the comfort of using other forms and having the built infrastructure of technologies, such as provider portal and secure messaging, with the adoption of telehealth technologies. For those without resources for telehealth technology but considering it, it appears organizational service type and control structure are significantly related. Although general care providers may be placed in the position of being ready, willing, and able more often than specialties, there is a need for more specialist providers to take part in telehealth exchanges with general providers. More research needs to be done on how multilevel factors affect the ability of organizations to adopt telehealth. There is no national database for telehealth information, this would be useful to examine the complex systems of adopting multiple types of telehealth technology. Research that encompasses more factors related to telehealth could lend to finding the level at which changes should take place to promote the diffusion of organization advancing telehealth technology.

Chapter 4: A Mixed-Method Study on the Perceived Barriers to Telehealth Adoption and Overcoming Challenges with Sustainability in Nebraska.

I. Introduction:

There are many external environmental factors and internal organizational issues that can put up roadblocks to the adoption of a sustainable telehealth program. Factors such as reimbursement policies, low demand for services, and a highly competitive

market can all affect the adoption of telehealth technology. Relationships among providers may lead to a reluctance to collaborate to achieve economies of scale.[87,88] Many rural areas struggle to retain health care providers and lack the personnel capacity to take on the additional workload related to telehealth services.[3] On the other hand, telehealth can also increase resources for rural areas, by utilizing technology to reach providers when none are readily available locally.[87] For already struggling hospitals, the cost of equipment, implementation, and maintenance can be a burden that is too high. Even if there are the financial resources, particularly in rural areas, there is a lack of information technology (IT) specialists. [87]

Barriers related to those partaking in telehealth services include the lack of perceived value of the technology, providers may see the new technology as an inconvenience, something that will require more time, scheduling hassles, and coordination. [87,89–91] Patients may not feel comfortable receiving care through a certain form of technology, or the technology is not portable enough to be useful to the provider or the patient. [87,89,91] Conversely, some telehealth research has found that scheduling can be improved and cut down on no-shows by allowing patients to avoid long travel times. [88,92] One large issue with telehealth technologies that is often mentioned is the concern of privacy of patient data and the increased liability that may come with telehealth use. This is made more confusing due to the lack of clear and consistent policies related to licensing across states and the types of credentialing needed to use the technology and be reimbursed.[87,89,93]

Nebraska has several definitions of telehealth within their legislation, including a definition of telemonitoring within the Medicaid program code.[17] Nebraska Medicaid

covers telehealth services at the same rate as in-person services for technology that meets Health Insurance Portability and Accountability Act of 1996 (HIPAA) compliant requirements. The payment, however, is not made to the referring healthcare practitioner and is only made to the consulting healthcare provider after they report back to the referring clinic.[17] The Medicaid regulations are quite complex for telehealth reimbursement in Nebraska. Mental health providers cannot use telehealth consultation for urgent conditions requiring immediate assistance, but they can be used for children's behavioral health as long as a trained staff member is available or if the guardian waives the need for a trained staff member to be nearby.[17] To add more complications Assertive Community Therapy Team interventions can be provided via telehealth but a safety plan must be in place for clients, except children receiving behavioral health services.[17]

Although telehealth has been touted as a way to provide access to rural and underserved populations, core services of Federally Qualified Health Centers and Rural Health Clinics are not covered by Medicaid if delivered via telehealth.[17] For store and forward technology, Nebraska Medicaid will only reimburse for teleradiology. Telemonitoring services are covered at a daily per diem-rate which includes the review and interpretation of data, the equipment and supplies used, medically necessary visits to the home by a healthcare practitioner, and training on the use of the equipment.[17] This is an improvement over many states who have yet to cover RPM technologies or determine the correct way to reimburse for them. The previous confusion of the mental health telehealth services which could be seen as a limitation is in contrast to this RPM promoting reimbursement policy that covers equipment and training.[17]

Nebraska does require written or email consent before the initial telehealth services can be delivered. This is separate from the usual consent and HIPAA information. The telehealth service consent must inform patients of other care options, the existing laws, and protections, whether the consultation will be recorded, and told of the personnel or providers who will be involved and has the option to exclude any of the participants.[17] There is no cross-state licensing in Nebraska, which may be due to the large Omaha service radius that extends into Iowa. The state does not require private payers to reimburse for telehealth services. The only requirement for private payers is that upon request they must provide a description of the telehealth services covered by the policy, including a description of the services, exclusions and limitations, and the state licensing and signed written consent requirements.[17] This is only one states labyrinth of Medicaid reimbursement policy, which gives a prime example of the difficulty of navigating the ever-changing regulations for telehealth services.

A few researchers have tried to create lists or frameworks for the needs of a sustainable telehealth program[6,94,95] but it is nearly impossible in a real healthcare environment to meet all the requirements, not to mention that some requirements may be more pressing in one area than another. Telehealth is a node in the complex socio-technical system (CSTS) of healthcare. Stakeholders at multiple levels across differing fields must align goals to create, implement, and then sustain telehealth. Innovations such as telehealth should not be taken on for the sake of being innovative, they need to fit the goal of the organization and lead to a proposed outcome. [89]

This study fills a gap in the current literature related to barriers of implementation and sustainability of different telehealth technology by building interview questions from

state-specific data. It explores overcoming barriers related to implementation, recurring payment availability, sustainability issues, and the perceived benefits for both providers and patients. This mixed methods study focuses on the state of Nebraska as it is one of the few states who track healthcare professionals. However, the insights developed in this mixed method study advances future studies and leads to a better understanding of how individual clinics are operating telehealth services within real-world healthcare practices. This study informs on the sustainability of telehealth services in a state with vastly differing geographic populations. In the eastern part of the state, there are two larger urban hubs, Omaha and Lincoln. Conversely, the rurality of the state grows as you move west, with several counties designated as frontier counties.

The **aim** of this mixed methods sequential explanatory study is to determine the forms of telehealth technology services utilized in Nebraska clinics and the associated barriers for each form of technology by obtaining quantitative results from a telemedicine survey of Nebraska clinics, and develop a deeper understanding of the challenges faced with adopting and sustaining telehealth services through interviews of a maximal variation sampling of surveyed clinics and qualitative case study analysis.

.***Methods:***

Quantitative Research Questions:

- How are Nebraska clinics utilizing telehealth technologies (i.e. live, store and forward, RPM)?
- Is live video the predominant form of telehealth technology being used?
- What are the barriers most closely associated with the different forms of telehealth technology?

Quantitative Hypotheses:

- Different barriers will be perceived by physicians using different types of technology due to the different requirements to perform services with the technology.
- Clinics with an older average age will be less likely to use telehealth technology, related to comfort of use.

Qualitative Research Questions:

- What were the decision-making factors for adoption of a telehealth service system?
- How are clinics providing telehealth services overcoming the noted barriers from the survey?
- What are the plans for continued sustainability?

Mixed Methods Research Question:

- To what extent can the qualitative interviews of telehealth clinical staff contribute to a more comprehensive understanding of the quantitative survey data related to barriers of adoption and subsequent sustainability of telehealth services in Nebraska?

This study is a sequential explanatory mixed methods design, with emphasis on the qualitative portion and its ability to deepen the understanding of the quantitative findings. In sequential mixed methods design, the quantitative and qualitative portions are done chronologically, for explanatory design the quantitative data is collected first, and interpreted, which is followed by the qualitative data collection and interpretation, with the completion of the study when both portions are integrated.[96–102] Sequential

explanatory mixed methods design is most often used to explain the initial quantitative results with the qualitative portion of the study.[96,97,99,102,103] It can also be used to form groups based on the quantitative research or to guide purposeful sampling of the qualitative phase with the quantitative results.[97]Although most sequential explanatory design studies emphasize the quantitative portion, [97,100,102] the quantitative portion of this study does not fully address the question. It gives an overview of the large categories (live, store and forward, and RPM) that are used and reimbursed for in the state of Nebraska. The quantitative data collection also surveyed on barriers but not in the particulars of overcoming the barriers and future sustainability. The quantitative portion informs the interview questions and the groups of clinics chosen for sampling in the qualitative portion. The qualitative portion helps to explain the initial quantitative results and expand on their interpretation.[97,100,102]

Both the quantitative and qualitative research designs fall within the case study approach, as the data collected by the quantitative portion is limited to clinics within Nebraska that responded to the Health Professions Tracking Services (HPTS) survey. The sample of clinics interviewed for the collection of qualitative data was a small purposive selection of clinics meeting specific requirements for maximum variation sampling. All study activities were approved by the University of Nebraska Medical Center Institutional Review Board. Case study research involves developing an in-depth analysis through a single case or multiple cases. [96,104] The case study approach is used to focus on the how and why questions of a study, particularly when a researcher cannot manipulate the behavior of the participants and the boundaries between the phenomenon or intervention and the context are not clearly defined.[104,105] The case study approach allows

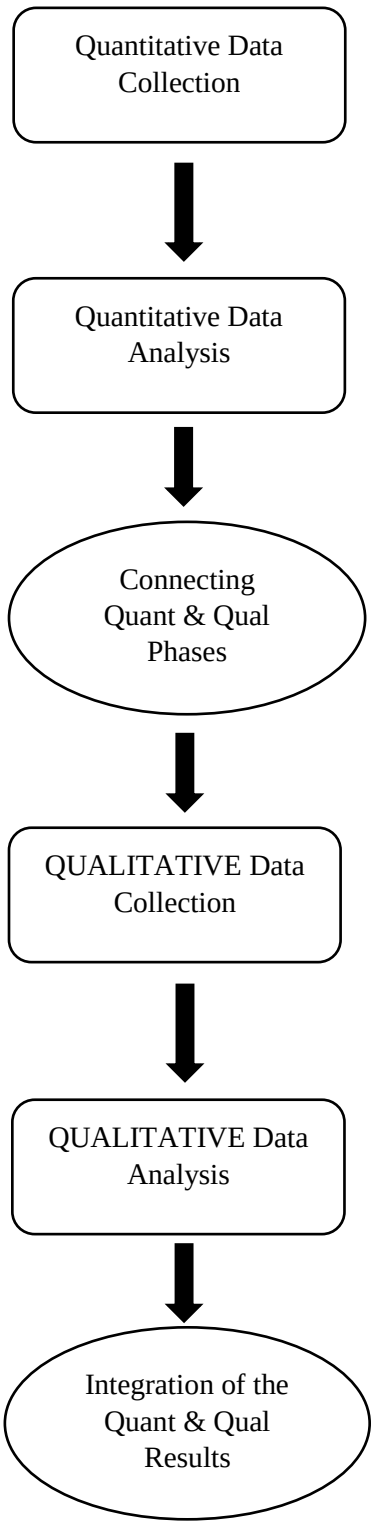
the researcher to cover the contextual conditions believed to be relevant to the phenomenon of the study, [105] in this study it is the barriers of implementation and sustainability and the use of telehealth technology in clinic services. The case study approach is characterized by the use of multiple data collection methods and therefore lends to the sequential explanatory mixed methods design of this study.

The rationale for using this form of mixed methods research design is that the qualitative arm of the study builds on the quantitative portion and can lead to a greater understanding of the research questions that cannot be reached by either portion alone.[102] The quantitative data collection and analysis would only provide an overview of the trend and would not touch on the why and how of the research aim. The qualitative data collection is reliant on the outcomes of the quantitative results and the sample for interviewing is determined by these results as well. By combining both forms of data collection and results through integration at several points in the study design, we can have a more robust understanding of the research questions and aim of the study, by taking advantage of the strengths of each. [102]

Quantitative Research Design:

Figure 4.1 is a visual diagram of the procedures followed to conduct this study and the product of each phase of the study.

Figure 4.1: Visual Model of Sequential Explanatory Design Procedures



	Procedure	**Product**
Quantitative Data Collection	• Nebraska clinics determined • Survey mailed to 1580 clinics on 06/15/2017 by HPTS • Reminder request sent on 07/14/2017 to non-respondents • Data from returned surveys recorded in Excel file	• Data for 573 Nebraska Clinics
Quantitative Data Analysis	• Descriptive analysis • Remove duplicate responses • Chi-square factor analysis • Univariate logistic regression • Multivariate Logistic regression • Done with STATA 14 software[106]	• Descriptive Statistics • Associated barriers to multiple technology types • Clinic organizational makeup associations with technology
Connecting Quant & Qual Phases	• Maximum variation sampling determined from quant results • Purposefully select 5 clinics from each telehealth technology group. • Develop interview questions	• Cases (*n*=15) • Interview protocol
QUALITATIVE Data Collection	• Individual in-depth telephone interviews with 15 clinic telehealth providers/coordinators • Provide email and phone for follow-up thoughts • Record interview via two digital recorders • Transcribe each recorded interview verbatim	• Text data from transcribed interviews
QUALITATIVE Data Analysis	• Coding and thematic analysis • Within group and across-group theme development • Cross-theme comparisons • NVivo 11 qualitative software[107]	• Visual model of multiple case analysis • Code and themes similar and different themes and categories • Cross-theme narrative
Integration of the Quant & Qual Results	• Interpretation of quantitative and qualitative results • Themes of qualitative linked back to quantitative findings	• Discussion • Implications for the field • Future research

In the first phase of the study, the quantitative data collection was done by the HPTS, which included a telehealth supplemental survey.[108] The telemedicine survey was included in the bi-annual survey sent to clinics on May 15, 2017. A follow-up request for completion of the survey was sent on July 14, 2017, to non-respondents. The surveys were separated into two groups, solo practices that are identified as an individual practice location not associated with a group. The second group was a parent/child group of practice locations. These clinics can be grouped, even if it is not necessarily a legal contract between clinics, because the facilities have identified a single source for the survey verification. For example, small hospitals may request all surveys be sent to a single recipient. Clinics with satellite locations may also designate a "parent" site to handle the survey for all clinics.[108]

Telemedicine surveys were sent to 1, 277 solo clinics and 367 parent clinics. There are 1,580 parent/child clinics in the HPTS data, but only the parent clinic is surveyed. After the removal of duplicates and the merging of the bi-annual survey responses, the total number of clinics that responded was 565, which equates to a 34.4% response rate. This sample was further reduced during analysis due to missing answers for key questions related to the research study aims and research questions, leaving a total of 334 clinics.

Within the main survey of clinics in Nebraska, there are specific questions about hospital/health system affiliation, the proportion of patients covered by different forms of insurance, and information about integrated care in the clinics. HPTS also sends out a profession specific survey once a year to healthcare providers practicing in Nebraska. The survey responses are designated into three groups, those providers who state a

location where they practice, those without a practice location and psychiatry services. The response rate for providers with a location is usually higher than those who do not have a practice location. Medical doctors and osteopathic doctors had an average response rate for all three categories of 37.3 percent, APRNs had an average response rate of 37.7 percent, and PAs average response rate was 47.3 percent.

The survey sent to different forms of providers (medical doctors, nurses, and physician assistants) includes demographic information on the provider, such as age, ethnicity, sex, as well as, the primary service type of the clinic. The providers that list their location of practice are then added to the clinic's survey to be verified by the clinic as practicing at that location. The telehealth supplemental survey contains questions pertaining to the type of telehealth services provided and if the technology is between patient and provider or consultation between providers. The three forms of between patient and provider technology listed were live video, store and forward, and remote patient monitoring. Live video is a synchronous form of communication that uses audiovisual telehealth technology, such as videoconferencing. [109] Store and forward telehealth technology is asynchronous and is often used in radiology. The communication can consist of prerecorded video or images that are sent to the provider for diagnosis or using a form of secure email. [109] Remote patient monitoring is a form of personal health and medical data collection. This form of technology can be real-time or asynchronous; the data is collected through electronic devices used by the patient usually in their home and then relayed to the provider and healthcare staff. [109]

Within the telemedicine survey, there is also a section on barriers in which providers can choose from or write in those they have encountered. Clinics also have the

option to choose “Do not intend to implement telehealth or no perceived need” if they have no telehealth within the clinic, this answer when chosen deals with the readiness of the clinics to adopt telehealth. The providers that chose this answer failed to meet the precondition of readiness in not seeing the perceived need or benefit of telehealth adoption.

Before the analysis, the barriers within the HPTS telehealth survey were split into two groups based on when they might occur in the telehealth technology implementation/adoption process. The early stage barriers that would affect the readiness, willingness, and ability to implement were grouped. Those include:

- Communication infrastructure (including broadband access)
- Cost to implement or maintain the technology
- Credentialing in multiple facilities
- End-user technology comfort issues
- Licensing across state borders

The barriers that were more likely to occur after the technology was in use were grouped and dealt with the sustainability of the program, continued ability and potential willingness to continue services. These included:

- Medical Coding
- Reimbursement Denial
- Reimbursement Rates

The majority of the clinics within the HPTS data are free-standing clinics; however, some are connected to hospitals. However, many free-standing clinics are

affiliated with local hospitals. The service category was coded as a binary response due to a large number of specialties provided in survey responses. Many specialties were only noted by one clinic and did not warrant a separate category. The average age of the providers within the clinic was determined by individuals who responded to the professions survey that was linked to the bi-annual survey responses via facility code. This average age was then categorized to limit the number of small cell sizes for analysis. Data on the proportion of medical doctors (MDs) compared to advanced practice registered nurses (APRNs), and physician assistants (PAs) was determined by those professionals validated by the clinic in the bi-annual survey. All proportions were categorized to minimize small cell size for logistic regression and to yield the best-fitted model possible.

Utilizing the HPTS database, analyses were performed to determine the forms of technology used within the state (live video, store and forward, and RPM) and the most frequent barriers of those clinics utilizing telehealth in some form. As there were three forms of between patient and provider technology in the HPTS survey data, analyses were run for each type, to assess the hypotheses and research questions for the quantitative portion of this study. Chi-square analysis was performed with each of the multilevel factors associated with the hybrid conceptual framework as the dependent variable. Sensitivity analysis was then run by flipping the variables in a logistic regression so that the use of a telehealth technology was the dependent variable with the multilevel factors as the independent variables. Interaction terms were tested within the logistic regression to determine the effect on the included covariates. No interaction terms were found to be statistically significant. The same independent variables were

tested for each type of telehealth technology. This made for an easy comparison between telehealth technology groups to determine the differences in barriers and structure that are specific to that technology.

The results of these analyses were used to create the interview questions that are related to barriers to implementation and sustainability and overcoming those barriers to sustain telehealth services. The overarching research question is how are Nebraska healthcare facilities using telehealth, overcoming barriers to adoption and sustaining their telehealth services?

Qualitative Research Design:

After the quantitative analyses, the results were used to identify the sample for each form of telehealth technology to be interviewed. Within the three types of technology that provided communication between providers and patients found within the HPTS survey, five clinics were chosen, for a total of 15 clinics. To guarantee completion of interviews to thematic saturation, a backup five clinics in each of the three groups were selected. The clinics within each group were chosen so that they noted the barriers most commonly associated with the technology they were using; there was also an attempt to vary the geographic area and service types of clinics in each group. This purposive sampling allowed for maximum variation which involves selecting a wide range of cases to get the most variation on those dimensions of interest and to generate diverse comparisons.[96,102,110,111] The goal of contacting several providers within each group yielding maximum variation is to reach thematic saturation. Thematic saturation has been achieved when there comes the point within interviewing at which no new information can be gathered from further interviews.[112–114] The number of interviews was chosen

with insight from literature review, Guest et al. (2006) and Ando et al. (2014) both suggest that saturation can be reached with 12 interviews and that further interviewing only lent to the small modification of thematic codes.[112,113]

Once the sample for interviewing was defined, the interview protocol was designed. The protocol included ten open-ended questions that were developed from the quantitative results used for in-depth interviews of telehealth service providers or coordinators. The interviews were for those individuals within the clinic that were very knowledgeable in the implementation of the technology and the daily use of the technology in clinical services. Clinics were contacted by telephone via the information given in the HPTS survey data, and the specific person able to answer the in-depth telehealth questions was determined. If the provider or coordinator was unable to take part in the interview at that moment, another time was set up to perform the interview by telephone.

Participants provided telephone interviews that were recorded by the use of a digital recorder and computer voice recorder to guarantee complete audio of each interview. These recorded interviews were then transcribed and analyzed using the NVivo 11 qualitative analysis software.[107] The analysis was coded by the interviewer and a 2nd coder for themes that are specific to Nebraska clinics and the barriers noted in the HPTS survey. Coding reports were summarized and cross-checked to ensure consistency of interpretation. Whenever differences in interpretations occurred, transcripts were reviewed again and discussed until consensus was achieved on the themes and subthemes.

The results from both the quantitative and qualitative portions of the study were then integrated to form more complete inferences and a greater comprehensive understanding of the barriers of adoption and sustainability of telehealth programs in Nebraska. [96,101,115] Table 4.1 is a visual representation of the technology categories, the associated barriers and the organizational factors that were used to guide the qualitative interview questions.

Table 4.1: Quantitative Factors Associated with Telehealth Technology Adoption Used to Guide Creation of Qualitative Interview Questions

Technology	Barrier	Organizational Factors
Live Video		
	Cost of Implementing and Maintaining Technology	Average Age of Providers
	Licensing Providers	Proportion of Medicaid Patients
	End-user comfort of use	Telehealth Capabilities between Providers
Store and Forward		
	Medical Coding Barrier	Average Age of Providers
		Proportion of MDs
		Proportion of Medicaid Patients
		Proportion of Medicare Patients
		Telehealth Capabilities between Providers
Remote Patient Monitoring		
	Medical Coding Barrier	Proportion of Medicaid Patients
	Reimbursement Denial Barrier	Telehealth Capabilities between Providers

MD: Medical Doctor

Interview Questions:

1. Can you describe the telehealth technologies you are using to provide services to your clinic's patients?

2. What is the extent of the telehealth services you provide?
    a. Prompt: Extent meaning departments, units, disease specific programs, providers involved.
3. What led to the decision to start using this technology and providing these forms of services?
4. Why was this type of technology chosen for this purpose?
5. How was cost of technology and support associated with the telehealth implementation?
    a. Prompt: Associated meaning part of decision making process, projected costs, perceived cost benefit.
6. Describe issues related to the comfort of use with the technology on either the provider or patient side.
    a. Prompt: Comfort of use meaning how did providers and/or patients perceive the use of the technology.
7. Can you tell me about any credentialing or licensing issues that arose specifically to providing telehealth services?
    a. Prompt: Any credentialing or licensing requirements specific for the form of technology being implemented or to meet legal requirements for provision of services.
8. How were the implementation barriers you've described overcome by the organization?
9. After services were implemented were there any other challenges experienced?
    a. Prompt: coding, reimbursement, funding, patient need

10. Finally, what is the projected future for the clinic's telehealth services?

    a. Prompt: expanding, maintaining, termination.

II. Results:

A. Quantitative Analyses Results:

HPTS Data Analyses

Table 4.2: Frequency of Use for Three Telehealth Technologies (N=334)

Use	Live Video	Store and Forward	Remote Patient Monitoring
Yes	67	16	11
No	267	318	323

Table 4.2 demonstrated the frequency with which each telehealth technology is used in the clinics that answered the HPTS survey. Answering the research question related to live video, it is much more common in use than either store and forward or remote patient monitoring. Approximately four times more clinics use live video than store and forward and six times more than RPM.

Live Video Analysis

Table 4.3 includes the frequencies of independent variable categories for the variable of use of live video telehealth technology. Of those who said yes to a barrier, the proportion using live video is greater than those who said no to that barrier. This may be due to experiencing the issue while implementing or using live video technology. The proportion who use live video of those who are affiliated with a hospital is larger than the proportion using live video of those clinics not affiliated with a hospital. The percentage using live video for the average clinic age of providers between 30-45 years old is over double the percentage of clinics using live video in either of the older age categories.

Table 4.3: Multilevel Independent Variables by Live Video Use Chi-square Test (N=334)

Variable	Category	Not Using Live Video (n = 267)		Using Live Video (n=67)		Chi-square
		n	%	n	%	
Service Category						0.001
	Primary Care	127	79.9	32	20.1	
	Specialty	140	80.0	35	20.0	
Hospital Affiliation						
	Not Affiliated	106	85.5	18	14.5	3.780*
	Affiliated with a Hospital	161	76.7	49	23.3	
Average Age of Clinic Providers						13.172**
	30-45 yo	77	68.7	35	31.3	
	46-55 yo	127	85.8	21	14.2	
	>56 yo	63	85.1	11	14.9	
Proportion of Healthcare Providers that are MDs						
	0-50%	122	76.7	37	23.3	1.951
	51-100%	145	82.9	30	17.1	
Proportion of Insured Patients						5.200*
	0-50%	186	76.9	56	23.1	
	51-100%	81	88.0	11	12.0	
Proportion of Medicaid Patients						3.909
	0-10%	147	84.0	28	16.0	
	11-30%	102	75.0	34	25.0	
	31-100%	18	78.3	5	21.7	
Proportion of Medicare Patients						1.402
	0-30%	143	81.7	32	18.3	
	31-50%	80	80.0	20	20.0	
	51-100%	44	74.6	15	25.4	
Telehealth Capabilities between Providers						9.520*
	None	188	82.8	39	17.2	
	Capture or Receive	29	63.0	17	37.0	
	Both	50	82.0	11	18.0	
Infrastructure Barrier						0.017
	No	221	80.1	55	19.9	
	Yes	46	75.0	12	25.0	
Cost to Implement and Maintain						0.180
	No	176	79.3	46	20.7	
	Yes	91	81.2	21	18.8	
Credentialing Multiple Sites Barrier						3.349
	No	228	81.7	51	18.3	
	Yes	39	70.9	16	29.1	
Licensing Barrier						7.342*
	No	240	82.2	52	17.8	
	Yes	27	64.3	15	35.7	
Comfort with Use Barrier						15.559*
	No	225	84.3	42	15.7	
	Yes	42	63.7	25	37.3	
Medical Coding Barrier						0.635
	No	243	79.4	63	20.6	

	Yes	24	85.7	4	14.3	
Claims Denial Barrier						0.007
	No	222	79.9	56	20.1	
	Yes	45	81.4	11	19.6	
Rate of Reimbursement Barrier						0.681
	No	219	80.8	52	19.2	
	Yes	48	76.2	15	23.8	
Not interested/Not a priority						27.149**
	No	173	72.7	65	27.3	
	Yes	94	98.0	2	2.0	

MD: Medical Doctor
***** $p \leq 0.05$
** $p \leq 0.001$

Table 4.4 is the univariate logistic regression analysis of the live video dependent variable with each independent covariate determined at differing levels of the RWA CSTS hybrid framework. The odds of using live video are significantly reduced for the two older average clinic age ranges when compared to the lowest average clinic age range. When the clinic age range is above 45 years old the odds of using live video decreases by approximately 62 to 64 percent. Having the majority of the clinic's patient population insured reduces the odds of using live video by 55% compared to those with a lower proportion of insured patients. Clinics that responded yes to experiencing comfort of use barriers or licensing barriers had higher odds of using live video. Indicating a comfort of use barrier increased the odds of using live video approximately three times and indicating a licensing barrier increases the odds by 2.5 times.

Table 4.4: Live Video Univariate Logistic Regression Analysis with Multilevel Factors (N=334)

Variable	Category	Odds Ratio	Std. Error	z	*p*-value	95% CI
Service Category						
	Primary Care	NA	NA	NA	NA	NA
	Specialty	0.992	0.272	-0.03	0.977	(0.580, 1.697)
Hospital Affiliation						
	Not Affiliated	NA	NA	NA	NA	NA
	Affiliated with a Hospital†	1.792	0.543	1.92	0.054	(0.989, 3.247)
Average Age of Clinic Providers						
	30-45 yo	NA	NA	NA	NA	NA

	46-55 yo**	0.364	0.113	-3.24	0.001	(0.197, 0.671)
	>56 yo*	0.384	0.148	-2.48	0.013	(0.180, 0.818)
Proportion of Healthcare Providers that are MDs						
	0-50%	NA	NA	NA	NA	NA
	51-100%	0.682	0.188	-1.39	0.164	(0.398, 1.170)
Proportion of Insured Patients						
	0-50%	NA	NA	NA	NA	NA
	51-100% *	0.451	0.161	-2.24	0.025	(0.224, 0.907)
Proportion of Medicaid Patients						
	0-10%	NA	NA	NA	NA	NA
	11-30%†	1.75	0.501	1.95	0.051	(0.998, 3.067)
	31-100%	1.458	0.797	0.69	0.490	(0.499, 4.259)
Proportion of Medicare Patients						
	0-30%	NA	NA	NA	NA	NA
	31-50%	1.117	0.355	0.35	0.727	(0.599, 2.083)
	51-100%	1.523	0.545	1.18	0.239	(0.756, 3.072)
Telehealth Capabilities between Providers						
	None	NA	NA	NA	NA	NA
	Capture or Receive *	2.825	0.998	2.94	0.003	(1.415, 5.645)
	Both	1.061	0.400	0.16	0.876	(0.506, 2.221)
Infrastructure Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.048	0.375	0.13	0.895	(0.520, 2.114)
Cost to Implement and Maintain						
	No	NA	NA	NA	NA	NA
	Yes	0.883	0.259	-0.42	0.672	(0.496, 1.570)
Credentialing Multiple Sites Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.834	0.615	1.81	0.071	(0.951, 3.539)
Licensing Barrier						
	No	NA	NA	NA	NA	NA
	Yes*	2.564	0.916	2.64	0.008	(1.274, 5.162)
Comfort with Use Barrier						
	No	NA	NA	NA	NA	NA
	Yes**	3.189	0.969	3.82	<0.001	(1.758, 5.785)
Medical Coding Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.643	0.359	-0.79	0.429	(0.215, 1.923)
Claims Denial Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.969	0.357	-0.09	0.932	(0.470, 1.996)
Rate of Reimbursement Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.316	0.440	0.82	0.411	(0.684, 2.533)
Not interested/Not a priority						
	No	NA	NA	NA	NA	NA
	Yes**	0.057	0.041	-3.93	<0.001	(0.014, 0.237)

MDs: Medical Doctors; CI: Confidence Interval

***** $p \leq 0.05$

** $p \leq 0.001$

†Marginally significant (0.051-0.060)
NA-Not Applicable, Comparison Group

Table 4.5: Live Video Multivariate Logistic Regression Analysis with Multilevel Factors (N=334)

Variable	Category	Odds Ratio	Std. Error	z	*p*-value	95% CI
Service Category						
	Primary Care	NA	NA	NA	NA	NA
	Specialty	0.897	0.317	-0.31	0.757	(0.448, 1.793)
Hospital Affiliation						
	Not Affiliated	NA	NA	NA	NA	NA
	Affiliated with a Hospital	1.399	0.498	0.95	0.344	(0.698, 2.806)
Average Age of Clinic Providers						
	30-45 yo	NA	NA	NA	NA	NA
	46-55 yo*	0.387	0.139	-2.64	0.008	(0.191, 0.784)
	>56 yo*	0.323	0.168	-2.17	0.030	(0.116, 0.895)
Proportion of Healthcare Providers that are MDs						
	0-50%	NA	NA	NA	NA	NA
	51-100%	1.091	0.367	0.26	0.797	(0.534, 2.111)
Proportion of Insured Patients						
	0-50%	NA	NA	NA	NA	NA
	51-100%	0.533	0.256	-1.31	0.190	(0.208, 1.365)
Proportion of Medicaid Patients						
	0-10%	NA	NA	NA	NA	NA
	11-30%*	2.215	0.831	2.12	0.034	(1.062, 4.621)
	31-100%	1.338	0.962	0.41	0.685	(0327, 5.478)
Proportion of Medicare Patients						
	0-30%	NA	NA	NA	NA	NA
	31-50%	1.039	0.445	0.09	0.929	(0.448, 2.407)
	51-100%	2.317	1.244	1.57	0.118	(0.809, 6.635)
Telehealth Capabilities between Providers						
	None	NA	NA	NA	NA	NA
	Capture or Receive *	2.665	1.306	2.00	0.045	(1.020, 6.962)
	Both	1.000	0.408	0.00	0.999	(0.449, 2.227)
Infrastructure Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.935	0.475	-0.13	0.894	(0.345, 2.531)
Cost to Implement and Maintain						
	No	NA	NA	NA	NA	NA
	Yes†	0.453	0.185	-1.94	0.052	(0.204, 1.008)
Credentialing Multiple Sites Barrier						
	No	NA	NA	NA	NA	NA
	Yes	2.354	1.219	1.65	0.098	(0.853, 6.497)
Licensing Barrier						
	No	NA	NA	NA	NA	NA
	Yes	2.000	1.119	1.24	0.216	(0.668, 5.990)

Comfort with Use Barrier						
	No	NA	NA	NA	NA	NA
	Yes*	2.616	1.019	2.47	0.014	(1.219, 5.615)
Medical Coding Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.641	0.506	-0.56	0.573	(0.136, 3.012)
Claims Denial Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.957	0.565	-0.07	0.941	(0.301, 3.043)
Rate of Reimbursement Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.805	0.440	-0.40	0.691	(0.275, 2.352)
Not interested/Not a priority						
	No	NA	NA	NA	NA	NA
	Yes**	0.060	0.043	-3.92	<0.001	(0.015, 0.256)

MDs: Medical Doctors; CI: Confidence Interval
***** $p \leq 0.05$
** $p \leq 0.001$
†Marginally significant (0.051-0.060)
NA-Not Applicable, Comparison Group

Table 4.5 contains the results of the multivariate logistic regression controlling for multiple covariates associated with barriers and clinic system structure and operational processes. When controlling for all other variables, increased average age is still significantly associated with decreasing the odds of using live video. A proportion of Medicaid patients between 10% and 30% increases the odds of using live video compared to clinics with a proportion of less than 10% Medicaid patients. However, this increased odds does not transition to those clinics who have more than 30% Medicaid patients compared to those with less than 10%; this may be due to the very small number of clinics that have a proportion of patients of more than 30% covered by Medicaid. Comfort of use increased the odds of using live video by 2.6 times when controlling for all other variables. In this analysis, when the barrier of cost was perceived clinics were 55% less likely to use live video compared to clinics who did not perceive cost as a barrier. Finally, in both the univariate and multivariate regression models, clinics that had

no interest or did not see the use of live video as a priority had staggeringly decreased (0.06) odds of using live video.

Store and Forward Analysis

The same analyses were run for store and forward technology use. Table 4.6 shows the tabulation and chi-square results for each independent variable compared to the use of store and forward technology. The proportion that uses store and forward (S&F) for clinics affiliated with a hospital is more than double the proportion of clinics that use store and forward that are not affiliated with a hospital. The proportion of clinics using store and forward when the providers at the clinic are mostly (medical doctors) MDs is greater than the proportion of clinics that use S&F but have a minority of providers that are MDs. Clinics that have some form of telehealth communication between providers have a greater proportion of clinics using S&F than those clinics without telehealth communication between providers. Clinics that cited medical coding for S&F reimbursement had over three times the percentage of clinics using S&F compared to the percentage of clinics using store and forward for those that did not state coding as a barrier.

Table 4.6: Multilevel Independent Variables by Store and Forward Use Chi-square Test (N=334)

Variable	Category	Not Using Store and Forward (n=318)		Using Store and Forward (n = 16)		Chi-square
		n	%	n	%	
Service Category						0.039
	Primary Care	151	95.0	8	5.0	
	Specialty	167	95.4	8	4.6	
Hospital Affiliation						0.249
	Not Affiliated	119	96.0	5	4.0	
	Affiliated with a Hospital	199	90.0	11	10.0	

Average Age of Clinic Providers						0.829
	30-45 yo	107	95.5	5	4.5	
	46-55 yo	142	96.0	6	4.0	
	>56 yo	69	92.2	5	6.8	
Proportion of Healthcare Providers that are MDs						5.610*
	0-50%	156	98.1	3	1.9	
	51-100%	162	93.6	13	7.4	
Proportion of Insured Patients						0.055
	0-50%	230	95.0	12	5.0	
	51-100%	88	95.7	4	4.3	
Proportion of Medicaid Patients						0.830
	0-10%	167	95.4	8	4.6	
	11-30%	130	95.6	6	4.4	
	31-100%	21	91.3	2	8.7	
Proportion of Medicare Patients						5.573
	0-30%	170	97.1	5	2.9	
	31-50%	91	91.0	9	9.0	
	51-100%	57	96.6	2	3.4	
Telehealth Capabilities between Providers						24.549**
	None	225	99.1	2	0.9	
	Capture or Receive	39	84.8	7	15.2	
	Both	54	87.5	7	11.5	
Infrastructure Barrier						0.682
	No	264	95.7	12	4.3	
	Yes	54	93.1	4	6.9	
Cost to Implement and Maintain						2.045
	No	214	96.4	8	3.6	
	Yes	104	92.8	8	7.1	
Credentialing Multiple Sites Barrier						0.064
	No	266	95.1	13	4.9	
	Yes	52	94.6	3	5.4	
Licensing Barrier						0.583
	No	279	95.5	13	4.5	
	Yes	39	92.9	3	7.1	
Comfort with Use Barrier						3.188
	No	257	97.3	10	2.7	
	Yes	61	91.0	6	9.0	
Medical Coding Barrier						6.042*
	No	294	96.1	12	3.9	
	Yes	24	85.7	4	14.3	
Claims Denial Barrier						0.816
	No	266	95.7	12	4.3	
	Yes	52	92.8	4	7.1	
Rate of Reimbursement Barrier						0.414
	No	259	95.6	12	4.4	
	Yes	59	93.7	4	6.3	
Not interested/Not a priority						4.151*
	No	223	93.7	15	6.3	
	Yes	95	99.0	1	1.0	

MDs: Medical Doctors
***** $p \leq 0.05$
** $p \leq 0.01$

Univariate analysis for each multi-level independent variable was conducted for the use of store and forward technology. When the clinic had the majority of their providers as MDs, they were four times more likely to use S&F than those that had 50 percent or less of providers as MDs. The odds of using S&F technology also increased with the proportion of Medicare patients at the clinic. Most significantly between those clinics with the least amount of Medicare patients (0-30%) and those clinics that had 30 to 50% of their patients covered under Medicare. The lack of significance for clinics with Medicare patient proportions above 50% for the slightly increased odds of using S&F could relate to the minimal number of clinics that have Medicare patients as the majority of their patients. The ability to communicate between providers via telehealth greatly increased the odds of using S&F technology compared to those that had no between provider telehealth communication capabilities. The perceived barrier that is related to an increase in the odds of using S&F is medical coding. This is a barrier that could only be perceived after the start of a telehealth service upon trying to get reimbursement for services rendered.

Table 4.7: Store and Forward Univariate Logistic Analysis with Multilevel Factors (N=334)

Variable	Category	Odds Ratio	Std. Error	z	*p*-value	95% CI
Service Category						
	Primary Care	NA	NA	NA	NA	NA
	Specialty	0.904	0.464	-0.20	0.844	(0.331, 2.472)
Hospital Affiliation						
	Not Affiliated	NA	NA	NA	NA	NA
	Affiliated with a Hospital	1.316	0.727	0.50	0.620	(0.445, 3.885)
Average Age of Clinic Providers						
	30-45 yo	NA	NA	NA	NA	NA
	46-55 yo	0.904	0.560	-0.16	0.871	(0.268, 3.047)
	>56 yo	1.551	1.011	0.67	0.501	(0.432, 5.566)
Proportion of Healthcare Providers that are MDs						

	0-50%	NA	NA	NA	NA	NA
	51-100%*	4.173	2.718	2.19	0.028	(1.164, 14.954)
Proportion of Insured Patients						
	0-50%	NA	NA	NA	NA	NA
	51-100%	0.871	0.515	-0.23	0.816	(0.273, 2.778)
Proportion of Medicaid Patients						
	0-10%	NA	NA	NA	NA	NA
	11-30%	0.963	0.533	-0.07	0.946	(0.326, 2.850)
	31-100%	1.988	1.640	0.83	0.405	(0.395, 10.016)
Proportion of Medicare Patients						
	0-30%	NA	NA	NA	NA	NA
	31-50% *	3.363	1.929	2.11	0.034	(1.093, 10.349)
	51-100%	1.193	1.016	0.21	0.836	(0.225, 6.334)
Telehealth Capabilities between Providers						
	None	NA	NA	NA	NA	NA
	Capture or Receive **	20.192	16.589	3.66	<0.001	(4.035, 101.04)
	Both **	14.583	11.918	3.28	0.001	(2.939, 72.354)
Infrastructure Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.630	0.973	0.82	0.414	(0.505, 5.254)
Cost to Implement and Maintain						
	No	NA	NA	NA	NA	NA
	Yes	2.058	1.059	1.40	0.161	(0.750, 5.645)
Credentialing Multiple Sites Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.180	0.778	0.25	0.801	(0.324, 4.297)
Licensing Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.651	1.096	0.76	0.450	(0.449, 6.065)
Comfort with Use Barrier						
	No	NA	NA	NA	NA	NA
	Yes	2.528	1.356	1.73	0.084	(0.883, 7.235)
Medical Coding Barrier						
	No	NA	NA	NA	NA	NA
	Yes*	4.083	2.516	2.28	0.022	(1.221, 13.659)
Claims Denial Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.705	1.019	0.89	0.372	(0.528, 5.503)
Rate of Reimbursement Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.463	0.872	0.64	0.523	(0.455, 4.706)
Not interested/Not a priority						
	No	NA	NA	NA	NA	NA
	Yes	0.156	0.163	-1.78	0.075	(0.020, 1.205)

MDs: Medical Doctors; CI: Confidence Interval
***** $p \leq 0.05$
** $p \leq 0.001$
†Marginally significant (0.051-0.060)
NA-Not Applicable, Comparison Group

Table 4.8: Store and Forward Multivariate Logistic Analysis with Multilevel Factors (N=334)

Variable	Category	Odds Ratio	Std. Error	z	*p*-value	95% CI
Service Category						
	Primary Care	NA	NA	NA	NA	NA
	Specialty	0.291	0.222	-1.62	0.106	(0.65, 1.299)
Hospital Affiliation						
	Not Affiliated	NA	NA	NA	NA	NA
	Affiliated with a Hospital	0.731	0.527	-0.43	0.664	(0.178, 3.003)
Average Age of Clinic Providers						
	30-45 yo	NA	NA	NA	NA	NA
	46-55 yo	1.735	1.507	0.63	0.526	(0.316, 9.521)
	>56 yo*	5.780	4.979	2.04	0.042	(1.068, 31.273)
Proportion of Healthcare Providers that are MDs						
	0-50%	NA	NA	NA	NA	NA
	51-100%*	13.232	11.882	2.88	0.004	(2.276, 76.912)
Proportion of Insured Patients						
	0-50%	NA	NA	NA	NA	NA
	51-100%	2.035	1.844	0.78	0.433	(0.344, 12.024)
Proportion of Medicaid Patients						
	0-10%	NA	NA	NA	NA	NA
	11-30%	3.482	2.960	1.47	0.142	(0.658, 18.428)
	31-100%*	41.121	52.838	2.89	0.004	(3.314, 510.28)
Proportion of Medicare Patients						
	0-30%	NA	NA	NA	NA	NA
	31-50% **	19.031	17.566	3.19	0.001	(3.117, 116.18)
	51-100%	3.301	4.310	0.91	0.360	(0.255, 42.659)
Telehealth Capabilities between Providers						
	None	NA	NA	NA	NA	NA
	Capture or Receive **	87.541	96.683	4.05	<0.001	(10.049, 762.63)
	Both **	43.768	40.687	4.07	<0.001	(7.078, 270.67)
Infrastructure Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.832	0.676	-0.23	0.821	(0.169, 4.085)
Cost to Implement and Maintain						
	No	NA	NA	NA	NA	NA
	Yes	1.488	1.470	0.40	0.688	(0.214, 10.322)
Credentialing Multiple Sites Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.639	0.613	-0.47	0.640	(0.098, 4.183)
Licensing Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.688	0.662	-0.39	0.698	(0.104, 4.540)
Comfort with Use Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.728	1.536	0.62	0.538	(0.303, 9.863)

Medical Coding Barrier						
	No	NA	NA	NA	NA	NA
	Yes*	8.875	8.126	2.38	0.017	(1.475, 53.395)
Claims Denial Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.754	0.788	-0.27	0.787	(0.097, 5.854)
Rate of Reimbursement Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.673	0.907	-0.29	0.769	(0.048, 9.461)
Not interested/Not a priority						
	No	NA	NA	NA	NA	NA
	Yes**	0.052	0.042	-3.61	<0.001	(0.010, 0.258)

MDs: Medical Doctors; CI: Confidence Interval
***** $p \leq 0.05$
** $p \leq 0.001$
†Marginally significant (0.051-0.060)
NA-Not Applicable, Comparison Group

The multivariate logistic regression analysis controlled for all the independent variables that were examined within the univariate analysis associated with S&F use in Nebraska clinics. The results of this regression are found in Table 4.8. Unlike live video, increased odds of using S&F technology is associated with older age when compared to the youngest average age range of clinic providers. Store and forward technology may be easier to use than live video as it is the transmission of data asynchronously, similar to email or sending data not in real time. However, it may not be the preferred technology for younger providers who want higher levels of technology for their work with patients.

Clinics with the majority of providers being MDs had significantly greater odds of using S&F compared to those with more APRN and PA providers. As teleradiology is the only form of S&F telehealth covered by Medicaid in the state of Nebraska, this could relate to the 13.2 times greater odds, as a radiologist MD would need to read the data sent via S&F. Greater proportions of either Medicare or Medicaid covered patients at a clinic increased the odds of using S&F, when compared to those clinics with the lowest proportion of Medicare or Medicaid patients. As in the univariate analysis, when

controlling for all other factors between provider telehealth communication capabilities and perceiving medical coding as a barrier both increased the odds of using S&F technology significantly.

Remote Patient Monitoring Analysis:

There were much fewer clinics performing RPM than live video in the state of Nebraska. This led to the need to perform Fisher's exact testing due to the small sample size in several category cells. The only barrier that was determined to be associated with the use of RPM was infrastructure when chi-square was performed. The proportion of clinics using RPM is much greater in those clinics that have more between provider telehealth communication capabilities than the proportion of clinics using RPM when clinics have no between provider communication capabilities. The barrier of not interested or not prioritizing RPM technology in the clinic was not included in any of the RPM analysis due to multiple cells containing zero.

Table 4.9: Multilevel Independent Variables by RPM use Chi-square Test (N=334)

Variable	Category	Not Using RPM (n=323)		Using RPM (n=323)		Chi-square
		n	%	n	%	
Service Category						0.576
	Primary Care	155	87.5	4	2.5	
	Specialty	168	96.0	7	4.0	
Hospital Affiliation						0.003
	Not Affiliated	120	96.8	4	3.2	
	Affiliated with a Hospital	203	96.7	7	3.3	
Average Age of Clinic Providers						0.483
	30-45 yo	109	97.3	3	2.7	
	46-55 yo	142	96.0	6	4.0	
	>56 yo	72	97.3	2	2.7	
Proportion of Healthcare Providers that are MDs						0.220
	0-50%	153	96.2	6	3.8	
	51-100%	170	97.1	5	2.9	
Proportion of Insured Patients						0.500
	0-50%	233	96.3	9	3.7	
	51-100%	90	97.8	2	2.2	

Proportion of Medicaid Patients						4.012
	0-10%	172	98.3	3	1.7	
	11-30%	130	95.6	6	4.4	
	31-100%	21	91.3	2	8.7	
Proportion of Medicare Patients						0.263
	0-30%	170	97.1	5	2.9	
	31-50%	96	96.0	4	4.0	
	51-100%	57	96.7	2	3.3	
Telehealth Capabilities between Providers						6.437*
	None	223	98.2	4	1.8	
	Capture or Receive	44	95.7	2	4.3	
	Both	56	91.8	5	8.2	
Infrastructure Barrier						0.778
	No	268	97.1	8	2.9	
	Yes	55	94.8	3	5.2	
Cost to Implement and Maintain						2.253
	No	217	97.8	5	2.2	
	Yes	106	94.6	6	5.4	
Credentialing Multiple Sites Barrier						0.966
	No	271	97.1	8	2.9	
	Yes	52	94.5	3	5.5	
Licensing Barrier						0.325
	No	283	96.9	9	3.1	
	Yes	40	95.2	2	4.8	
Comfort with Use Barrier						1.886
	No	260	97.4	7	2.6	
	Yes	63	94.0	4	6.0	
Medical Coding Barrier						1.422
	No	297	97.1	9	2.9	
	Yes	26	92.9	2	7.1	
Claims Denial Barrier						0.016
	No	269	96.8	9	3.2	
	Yes	54	96.4	2	3.6	
Rate of Reimbursement Barrier						2.277
	No	264	97.4	7	2.6	
	Yes	59	93.7	4	6.3	

MD: Medical Doctor
* $p \leq 0.05$

Table 4.10 displays the results of the univariate logistic regression for the use of RPM in relation to the multilevel factors used in the previous technology logistic regression models. Small cell sizes hinder the use of logistic regression to accurately determine the association; however, this analysis is used to inform the qualitative portion of the analysis. Two-way telehealth communication capabilities significantly increase the odds of using RPM by almost five times over clinics that have no telehealth communication between providers.

Table 4.10: RPM Univariate Logistic Analysis with Multilevel Factors (N=334)

Variable	Category	Odds Ratio	Std. Error	z	*p*-value	95% CI
Service Category						
	Primary Care	NA	NA	NA	NA	NA
	Specialty	1.615	1.029	0.75	0.452	(0.463, 5.633)
Hospital Affiliation						
	Not Affiliated	NA	NA	NA	NA	NA
	Affiliated with a Hospital	1.034	0.660	0.05	0.958	(0.296, 3.614)
Average Age of Clinic Providers						
	30-45 yo	NA	NA	NA	NA	NA
	46-55 yo	1.535	1.105	0.60	0.551	(0.375, 6.290)
	>56 yo	1.009	0.935	0.01	0.992	(0.164, 6.207)
Proportion of Healthcare Providers that are MDs						
	0-50%	NA	NA	NA	NA	NA
	51-100%	0.750	0.462	-0.47	0.641	(0.224, 2.511)
Proportion of Insured Patients						
	0-50%	NA	NA	NA	NA	NA
	51-100%	0.575	0.456	-0.70	0.486	(0.122, 2.721)
Proportion of Medicaid Patients						
	0-10%	NA	NA	NA	NA	NA
	11-30%	2.646	1.899	1.36	0.175	(0.648, 10.802)
	31-100%	5.460	5.150	1.80	0.072	(0.860, 34.672)
Proportion of Medicare Patients						
	0-30%	NA	NA	NA	NA	NA
	31-50%	1.417	0.969	0.51	0.611	(0.371, 5.412)
	51-100%	1.193	1.016	0.21	0.836	(0.225, 6.334)
Telehealth Capabilities between Providers						
	None	NA	NA	NA	NA	NA
	Capture or Receive	2.534	2.237	1.05	0.292	(0.449, 14.301)
	Both *	4.978	3.426	2.33	0.020	(1.292, 19.183)
Infrastructure Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.827	1.268	0.87	0.385	(0.469, 7.121)
Cost to Implement and Maintain						
	No	NA	NA	NA	NA	NA
	Yes	2.457	1.518	1.45	0.146	(0.732, 8.248)
Credentialing Multiple Sites Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.954	1.358	0.96	0.335	(0.501, 7.628)
Licensing Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.572	1.259	0.56	0.572	(0.327, 7.556)
Comfort with Use Barrier						
	No	NA	NA	NA	NA	NA
	Yes	2.358	1.517	1.33	0.182	(0.668, 8.321)
Medical Coding Barrier						
	No	NA	NA	NA	NA	NA

	Yes	2.538	2.054	1.15	0.250	(0.520, 12.400)
Claims Denial Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.107	0.882	0.13	0.899	(0.232, 5.279)
Rate of Reimbursement Barrier						
	No	NA	NA	NA	NA	NA
	Yes	2.557	1.647	1.46	0.145	(0.724, 9.036)

MDs: Medical Doctors; CI: Confidence Interval
* $p \leq 0.05$
NA-Not Applicable, Comparison Group

As with both live video and store and forward telehealth technology, RPM use was used as the dependent variable for multivariate logistic regression analysis with the multilevel factors from the RWA CSTS hybrid framework (Table 4.11). When controlling for all other factors the proportion of patients covered by Medicaid at the clinic significantly affected the odds of using RPM. Those clinics with the highest proportion of Medicaid covered patients were significantly more likely to use RPM than those who clinics with less than 10% of their patients covered by Medicaid. In Nebraska, RPM is covered by Medicaid and paid at a daily per diem-rate. Clinics that had two-way between provider communication via telehealth technology had 7.5 times greater odds of using RPM than those that had no telehealth communication between providers. Clinics that noted medical coding or rate of reimbursement as a barrier had greater odds of using RPM compared to clinics that responded no to these barriers. Clinics that cited claims denial as a perceived barrier had much lower odds of using RPM compared to clinics that did not cite this as a barrier after controlling for all variables.

Table 4.11: RPM Multivariate Logistic Analysis with Multilevel Factors (N=334)

Variable	**Category**	**Odds Ratio**	**Std. Error**	**z**	***p*-value**	**95% CI**
Service Category						
	Primary Care	NA	NA	NA	NA	NA
	Specialty	2.166	1.728	0.97	0.333	(0.453, 10.346)
Hospital Affiliation						
	Not Affiliated	NA	NA	NA	NA	NA

	Affiliated with a Hospital	1.133	0.836	0.17	0.866	(0.267, 4.809)
Average Age of Clinic Providers						
	30-45 yo	NA	NA	NA	NA	NA
	46-55 yo	2.214	2.025	0.87	0.385	(0.369, 13.297)
	>56 yo	1.365	1.658	0.26	0.798	(0.126, 14.755)
Proportion of Healthcare Providers that are MDs						
	0-50%	NA	NA	NA	NA	NA
	51-100%	0.806	0.727	-0.24	0.811	(0.138, 4.715)
Proportion of Insured Patients						
	0-50%	NA	NA	NA	NA	NA
	51-100%	1.308	1.431	0.25	0.806	(0.153, 11.165)
Proportion of Medicaid Patients						
	0-10%	NA	NA	NA	NA	NA
	11-30%†	6.253	5.893	1.94	0.052	(0.986, 39.663)
	31-100%*	19.575	21.142	2.75	0.006	(2.357, 162.57)
Proportion of Medicare Patients						
	0-30%	NA	NA	NA	NA	NA
	31-50%	2.243	2.203	0.82	0.411	(0.327, 15.377)
	51-100%	2.935	3.440	0.92	0.358	(0.295, 29.196)
Telehealth Capabilities between Providers						
	None	NA	NA	NA	NA	NA
	Capture or Receive	2.537	2.739	0.86	0.389	(0.306, 21.049)
	Both *	7.545	5.593	2.73	0.006	(1.764, 32.259)
Infrastructure Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.984	0.886	-0.02	0.986	(0.168, 5.749)
Cost to Implement and Maintain						
	No	NA	NA	NA	NA	NA
	Yes	1.721	1.573	0.59	0.553	(0.287, 10.322)
Credentialing Multiple Sites Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.314	1.732	0.21	0.836	(0.099, 17.386)
Licensing Barrier						
	No	NA	NA	NA	NA	NA
	Yes	1.258	1.105	0.26	0.794	(0.225, 7.035)
Comfort with Use Barrier						
	No	NA	NA	NA	NA	NA
	Yes	0.970	0.799	-0.04	0.970	(0.193, 4.879)
Medical Coding Barrier						
	No	NA	NA	NA	NA	NA
	Yes*	6.792	5.948	2.19	0.029	(1.221, 37.791)
Claims Denial Barrier						
	No	NA	NA	NA	NA	NA
	Yes*	0.118	0.114	-2.22	0.026	(0.018, 0.778)
Rate of Reimbursement Barrier						
	No	NA	NA	NA	NA	NA
	Yes†	5.733	5.225	1.92	0.055	(0.961, 34.209)

MDs: Medical Doctors; CI: Confidence Interval

* $p \leq 0.05$

†Marginally significant (0.051-0.060)
NA-Not Applicable, Comparison Group

B. Qualitative Analysis Results:

Interview Data Analyses

All manuscripts were transcribed verbatim by the principal investigator, producing 13 interview transcripts. One clinic administrator provided their answers via email; this document was included in the coding, for a total of 14 clinic responses. Coding and analysis were conducted via NVivo 11 qualitative analysis software.[107] Two coders reviewed four of the transcribed interviews separately and developed a list of codes. The coders met to review the codes and developed a standard set of codes to use in reviewing all transcripts. The list of codes was categorized into four main overarching themes:

1. Telehealth technology use in Nebraska clinics
2. Implementation
3. Sustainability
4. Future of Services

There were 14 sub-themes within these categories. The coders utilized a constant comparison coding method to update codes throughout the analysis, coming together frequently to determine any changes or discrepancies in the coding scheme. The final coding scheme resulted in 13 sub-themes. Sub-themes included: Mode and Extent of Technology, Function of technology, Implementation Barriers, and Reimbursement.

The majority of clinical personnel who were interviewed were managerial staff, with only three individuals designated as telehealth coordinators. Those interviewed seemed to be both in-person and telehealth managerial staff, particularly in the smaller,

rural clinics. The final pool of clinics where personnel were interviewed contained seven rural clinics (population <10,000), four urban clinics (population > 50,000), and three clinics located in micropolitan areas. Six of the clinics were primary care facilities, and the other eight were a variety of specialties, including orthopedics, radiology, and behavioral health. The majority of the clinics that had staff interviewed for this study were affiliated with a hospital or health system, however, three were not. The proportion of Medicaid patients for clinics ranged from less than 5% to greater than 35%. The proportion of Medicare patients ranged from less than 10% to almost 80% of the clinic's patient population.

Most of the clinics interviewed primarily did live video, however, some clinics were doing more than one form of telehealth when providing services. The data from the HPTS survey was collected in the spring of 2017, and the interviews were conducted a year later leading to changes in technology use. One clinic had since ceased their telehealth services, and another had still yet to begin the telehealth services that were noted in the survey.

Telehealth technology use in Nebraska clinics

Mode of technology: The primary mode of technology mentioned by interviewees was live video chat. This was primarily done using a form of videoconferencing where the patient and the provider each had a camera, microphone, and screen set up so that they could see and hear one another for a live exchange, similar to in-person consultations. However, some facilities that were more specialty-focused had more specialized equipment, such as *"Philips telehealth stations to remotely monitor vital signs…"* and *"videoconferencing equipment that's connected to the ultrasound*

machine." For larger providers sending out services, they utilized all three technologies (live, store and forward, and RPM) to meet the needs of their clients. For example, one telehealth coordinator stated, "*The technologies that are involved include interactive video conferencing for a lot of the specialties services that are provided at remote locations. We also have remote patient monitoring technology,…, that includes not only a base unit in the patient's home but also scales, blood pressure cuff, and blood glucose currently. Those are in use, we also are working collaboratively through the epic portal."*

Extent of technology used: Most of the clinics used the telehealth technology throughout several departments. One manager stated, *"Outpatient wise we have a lot of different specialties, endocrinology, psychiatry, counseling, cardiology, nephrology, dermatology, and then we also do remote pharmacy services, antibiotic stewardship, things like that."* Radiology and psychiatry were the most noted areas of healthcare for the use of telehealth technology in providing services. Two facilities also stated that they use the telehealth technology to provide opportunities for continuing education for staff.

The extent of technology use for clinics ranged from a single link to another site to networking between multiple states. A very small clinic manager stated, "*We don't do a lot of telehealth here, I mean, so far this year I think we've had maybe one patient."* Compared to a large urban clinic affiliated with a hospital system, "*We're actually a provider of telemedicine services, so we work a lot with rural hospitals in Nebraska, Kansas, Iowa, Missouri, primarily.*" Most clinic staff stated that they had at least one connection outside the city in which the clinic was located.

Implementation

Reason to start using telehealth technology: Seven interviewed staff noted the clinic's location as a reason to start using telehealth; being located in a rural location and not having the correct type of provider in the area to meet patient needs. In one case the participant stated, "*Geography is totally the reason. We are extremely rural and very far from all specialties."* Only one specialty care facility stated that the reason they started using telehealth technology is to increase quality through decreased re-hospitalization rates and gain a competitive edge. The administrator stated, "*Our agency has made a decision to continue to invest in the program to assist with hospitalization rates and act as a differentiator with our competitors who do not offer it.*"

Another reason for starting telehealth services in the clinic was the distribution of grant money from larger hospitals in Nebraska, "*There was a grant numerous years ago, I can't even tell you how many years ago, but then I think it was Good Sam out of Kearney was the one that introduced us to it. And got us started with it."* Seven personnel from different clinics stated some form of grant funding was used to cover the cost of initial implementation and equipment.

Reason to start using that form of technology: There are three categories of telehealth technology noted in this study; however, there are several formats in which these categories can be delivered. Whether to use a store and forward function for sharing PDF files through an electronic health record or setting up RPM for home healthcare patients is determined by the needs of the clinic and the possible benefits to the clinic's patients. Most of the clinics with personnel interviewed used live video, the main reason to start using this form of technology to deliver services that was stated was it was most similar to in-person visit interactions. "*This is where the doctor and the*

patient can actually see each other face to face" and "*The live video at this moment was because that way doctors were actually face to face with the patient at that moment.*"

Implementation barriers: Due to the large proportion of technology purchased through grant funding, almost none of the clinic personnel noted the cost of technology or support as a barrier to implementing telehealth services. One telehealth coordinator stated, "*Pricing has been, especially from the perspective of interactive video conferencing, over the last ten to fifteen years has gone down significantly, and so we are able really to, from our side of the connection, that cost is very minimal. It still is a little higher at the remote location because often that is where the additional peripherals have to be located, because that is where the patients are located. We are more on the receiving end, so it's not as much of a need for those extra pieces of equipment, because we're the ones that are receiving the image or hearing the sound.*" Similarly, although cost was not an issue due to grant money, one interviewee recognized that without this assistance they would not have telehealth services, "*So really having those cost covered because we could never make that up, or we couldn't anyways, or maybe we're even afraid to try, to make that up in just the consultations alone. I know there would be ways to, with ordering you know, that there would be ancillary services that they would order labs or maybe x-ray, things like that but those are hard to quantify when you're doing your initial analysis.*"

Credentialing and cross-state licensure were not necessarily seen as a barrier but as a requirement that needed to be done. Some managerial personnel who were interviewed knew very little about credentialing as that was handled elsewhere, so it was assumed there were no issues; "*There hasn't been any comments that there has been any*

issues with that. Our medical director takes care of getting the credentialing done, and she has not made any comments about having problems doing that." Participants interviewed did note that the process of credentialing, even with proxy credentialing processes, could take 3 to 4 weeks. For example, "*Usually it's taken through med staff, um, when they apply through credentialing and within a month it's in front of our medical staff to sign off on.*"

For the few clinics that receive or provide telehealth services across state lines, there is a greater delay in getting providers licensed. One telehealth coordinator noted, "*It takes longer to get the physicians licensed, of course, we're going through that with a new service we are taking to a hospital down in a town in Kansas, it's taking us some time to get those physicians licensed. The compact seems to have helped with pieces of it, but it is still a process.*" There were a few participants that discussed the license compacts that are currently in place to help simplify the process for healthcare providers. For example, "*It's the multistate licensure compact for physicians and basically what that allows is, it does not allow reciprocity, so that's an important qualification, because the nurse compact does allow for reciprocity, the physician compact simply allows the cross-state license or the addition of another state licensure to be streamlined for that provider. So they are able to better, or walk through that process a little quicker."*

A barrier that was noted for implementation was physician perceptions of telehealth technology and the change the technology requires in workflow. One telehealth coordinator said, "*I think, you know, one of the main challenges is just having providers being willing to or being able and take the time to think outside of their current standard care delivery model. And that's part of the challenge, just having the time to address the*

potential for telehealth in their care environment." After a follow-up question about providers not wanting to use telehealth technology, a manager responded, "*Well yeah, but their choice is they either come on-site, or they use it, so that kind of puts them between a rock and a hard place, you know*." Another clinic manager also had ideas for overcoming physician reluctance, "*That you know is probably a big issue not maybe once they've used it but getting them to want to move forward with it. Physicians, in my opinion, physicians are a little reluctant to go outside of the box in terms of how they are taught to practice medicine, right? So you know good training and workflow implementation usually alleviate the comfort issue*." This clinic manager also stated that she would like to see telehealth methods taught in medical schools to prepare physicians for the changes required in workflow with its use.

Sustainability

Reimbursement: Most clinics had some form of reimbursement policy set up, meaning they charged patients or the insurer for the telehealth services in some way. One telehealth coordinator explained including telehealth services in a bundled payment, "*There are a lot of things that are traditional telehealth services certainly are a reimbursed service. There are some things that are incorporated as part of a bundled payment, for example if they, for example, orthopedic surgeries may be a bundled service, so a pre- and post-surgery visit would be incorporated into that, so there would not be a need for separate reimbursement as that is part of that package.*" There were a few clinics that were not currently seeking reimbursement, for example, "*We really haven't tried to get reimbursement on the newer stuff because the price is relatively reasonable and its, when we break it apart across the number of patients we're able to*

provide help to it's very reasonable." One clinic manager noted that they had a room charge for the visit but not for the services, while another clinic manager stated that they were only charging for the services and not the equipment costs. There was no exact standard for how the clinics were trying to obtain reimbursement or if they were going to at all.

A few of the clinics' personnel interviewed that were attempting to get reimbursed had some trouble with claims denials or receiving reimbursement payments. For instance, "*Not too badly, we've had blue cross a couple of times deny some services. We've worked with them to then resubmit, change some of the coding, and have been paid since. But you know, sometimes there's a couple extra hoops, here in Nebraska they've done a good job payer parity, so if the service is covered in person, it should also be covered by telemedicine.".* One specialized clinic that uses RPM to care for patients in the home had the most issues with reimbursement as the manager stated, "*Yea, so the biggest challenge is still reimbursement and healthcare laws, they are starting to change, but they still have a long way to go. I think the thought behind using telemedicine is to improve access for patients, to make access healthcare to healthcare easier for patients, right? Yet reimbursement prohibits that very challenge most insurance companies still will not reimburse for telemedicine when the patient is in the home.*" Most of the denial or claims issues are related to government policies on what, where, and who can be reimbursed for telehealth services.

Function of technology: The theme of the function of technology was divided into two prospective, the provider and the patient. The provider perspectives related to technology infrastructure and proper function to provide services, as well as, lack of staff

to cover the provision of telehealth services. Several interviewed clinic personnel noted issues with technology functioning properly. Most stated that it wasn't a major issue, but would happen from time to time, especially in the very rural areas. One clinic manager told of a recent incident where the technology malfunctioned, "*Just recently, we had a time when the doctor could see the patient, but the patient couldn't see the doctor, but he could hear the doctor. I mean they could still make the connection, but they couldn't both see each other. We have had that issue. There have been a couple times where they actually couldn't get connected at all. So, they didn't have their appointment, they had to reschedule the appointment. There have been a couple times that happened. But for the most part, it's worked pretty well.*" For the clinics that have dealt with this type of malfunction, they stated they overcame it through methods of reconnecting or rescheduling patients for another time once the problem had been resolved. However, when speaking with the staff member at the clinic no longer providing telehealth services, the barriers of long delays and turnaround times led to the decision to discontinue services; "*A stat read could take 24 to 72 hours for them to get back to us. Having to upload every image was hours' worth of work. So, we don't use them anymore.*"

The lack of personnel to work with the technology to provide services or adequately manage telehealth programs was also cited by some clinics. In one clinic the telehealth coordinator provided an example of the two telehealth knowledgeable staff members being absent, "*There are two of us in our department that know how to do it, it would be nice if a few other people, like one or two more people that could… We didn't know how to connect, although the burn unit in Lincoln,…was willing to do that for us,*

we were not sure on our end, how to make that connection happen on a Saturday afternoon. When there is minimal staff, and it had never been done before."

One clinic administrator listed issues both on the patient's side, with not using the technology correctly, and the devaluing of the telehealth services by providers and financial management staff. "*Variable patient compliance, anxious patients, taking vitals over and over instead of once per day as recommended; overuse of units on patients who did not have vital signs issues which lead to clinicians devaluing telehealth info. Lack of personnel to provide adequate program management, and financial agency management questioning value-add since cannot bill directly for the service.*" This clinic was the only one to list a competitive edge and increased quality indicators for a reason to start using telehealth. This may be the reason there is a concern for devaluing the telehealth services and seeing a lack of legitimization of the technology.

The patient perspective on the function of technology yielded a theme of comfort with technology use. Most patients were comfortable using the technology, despite their age. One interviewed manager stated, "*And patients, we've seen, even patients in their 80s, doing teleconsults and they just think it's great. They just love it! … we really haven't seen, you know, discomfort or a pain point with the comfort of using it. Maybe prior to using it the first and second time, there may be some you know discomfort. But once they've used it a time or two, you know, that went away.*" The theme of patients finding comfort after using the technology one or two times was noted in another interview, "*Patients I think after the first or second session they become comfortable with it. It just becomes natural, so I haven't had reports of people that did not want to do*

telehealth that refused telehealth. I think overall, that as people use it, it's become very comfortable for them."

Patient satisfaction was noted by several interview participants. One telehealth coordinator discussed the trepidation of providing services in communities with a higher rate of senior citizens, "*We thought going into some of these rural communities that folks would not be comfortable, especially the older folks, as you look at some of these rural communities, there's a lot of senior citizens in those communities. And you think, ah, they're just not going to accept this and in the first hospital that we started services in that was a little over 2 years ago, their emergency department patient satisfaction actually went up significantly, after we started providing services. So, we had a measurable increase in their satisfaction.*" Much of the satisfaction was attributed to the convenience of less travel for patients, especially senior patients. One rural clinic manager stated, "*Just that I think it is greatly appreciated by patients, especially elderly patients to reduce their driving time and their difficulty with getting rides to distant appointments.*" Another clinic manager also mentioned their prominently senior patient population and how telehealth has made it easier for them to obtain care, "*Right, most of those* [senior patients] *don't like driving in the cities at all, you know. And then they have to get a family member to get off work to get them somewhere. And from here we have a handi-bus that, if they notify them soon enough they can get them here, without the family having to bring them in too, so that helps too."*

Future of Telehealth Services in Nebraska

Future extent of services: The predominant perception of those clinic personnel interviewed was that telehealth services would grow, not only in their clinics but

throughout the state. For example, "*Yeah, I think as we mature our service lines, we may find some that we just can't build a sustainable model for and may need to re-prioritize some things. But I think the future points toward more, and, more, and more telemedicine use. Legislation hasn't completely caught up yet, but I think it will get there, especially as we are looking for ways to cut costs in health care. I think the future looks good for more services in the future and not less.*" For those few who noted that they did not see growth for their telehealth services in the future, much of this was due to issues networking with other sites.

The theme that was produced from the interview transcripts was the *barrier of networking across sites,* which dealt with finding physicians to network with and the standardization of technology. There was the need to network with different specialties, for example, "*Well I think they would like to use it in different specialties, but we don't have any that are interested in connecting with us at the moment. So, we're limited to what we have unless we can get someone else on board with it. So far no luck with that."* Another area of issue was the standardization of technology and communication for different sites that may not be from the same health system; "*The challenge is that as we stretch out to communities that don't have Epic or don't have our Epic we still will need to establish and understand a process to serve those folks as well*." Another manager noted, "*I don't know what department, but the issue a little bit, having the correct wires or connections, the T1 line getting through security, there have been some issues with firewall.*"

C. Mixed Method Analysis Results:

The quantitative data yielded barriers and organizational factors that could be associated with the implementation and sustainability of different types of telehealth technology in Nebraska clinics. The qualitative results produced detailed information on the reasons for the adoption of telehealth services, the barriers when implementing and using telehealth technology, and the future of telehealth in Nebraska clinics. Using Table 4.1 showing the overall significant barriers and organizational factors, in combination with the areas that were determined by the qualitative themes, a joint display was created. Table 4.12 is the joint display of the integrated results.

Table 4.12: Joint Display of Mixed Method Results

Live			
Theme Category	***Quantitative Results****	***Qualitative Theme***	***Qualitative Quote***
Telehealth technology use in NE clinics	Telehealth Capabilities	Purpose other than patient to provider	*"We will probably continue using it, it seems like more of our staff utilize it for education hours. But it seems like a lot of that technology is going to web-based programs."*
Telehealth technology use in NE clinics	Proportion of Medicaid Patients	Characteristics of Patients	"*Oh yea, we have kids that do telehealth up through geriatrics that do telehealth.*"
Implementation	End-user Comfort	Function of Technology: Patient Side	*"It's just a getting used to it issue and the nurses are skilled in getting the patients comfortable with it."*
		Patient Satisfaction	*"…in the first hospital that we started services in that was a little over 2 years ago, their emergency department patient satisfaction actually went up significantly, after we started providing services."*
		Physician Perceptions	*"I think, you know, one of the main challenges is just having providers being willing to or*

			being able and take the time to think outside of their current standard care delivery model. And that's part of the challenge, just having the time to address the potential for telehealth in their care environment."
NA	Age of Providers	No theme emerged related to the age of providers.	NA
Store and Forward			
Telehealth technology use in NE clinics	Proportion of Medicaid and Medicare Patients	Characteristics of Patients	No clinic reported on this theme for this form of telehealth.
Telehealth technology use in NE clinics	Telehealth Capabilities between Providers	Purpose other than patient to provider	No clinic reported on this theme for this form of telehealth.
Implementation	Proportion of MDs	Physician Perceptions of technology	*"That you know is probably a big issue not maybe once they've used it but getting them to want to move forward with it. Physicians in my opinion, physicians are a little reluctant to go outside of the box in terms of how they are taught to practice medicine."*
Sustainability	Medical Coding Barrier	Reimbursement	*"Not too badly, we've had blue cross a couple of times deny some services. We've worked with them to then resubmit, change some of the coding, and have been paid since."*
NA	Average Age of Providers	No theme emerged related to the age of providers.	NA
Remote Patient Monitoring			
Telehealth technology use in NE clinics	Proportion of Medicaid Patients	Characteristics of Patients	*"It's a variety, I mean, the OB/GYN clinic you know, your young ones, maternal fetal or high risk pregnancy patients. And then it goes all the way up to the elderly, who may need to see a GYN/urologist. It's really a wide range of patients and then we do the virtual urgent care which we see all ages in there."*

Telehealth technology use in NE clinics	Telehealth Capabilities between Providers	Purpose other than patient to provider	*"We also use a data exchange that allows us to upload imaging and any type of medical records that are in PDF form. And then those can be shared across the line of providers."*
Sustainability	Medical Coding Barrier	Reimbursement	*"Medicaid allows for reimbursement of remote patient monitoring as well as some of the other providers as well or insurance covers. So we are migrating into that process as well, is everything reimbursable? No."*
Sustainability	Reimbursement Denial Barrier	Reimbursement	"*Yet reimbursement prohibits that very challenge most insurance companies still will not reimburse for telemedicine when the patient is in the home.*"

NA-Not Applicable
*Results that were significantly associated with a form of telehealth technology use.

Due to the small number of clinics performing store and forward and remote patient monitoring, as well as, some variation in how clinical staff answered questions, some themes that were derived were only stated by providers using live video or RPM. Although it does not fit with any themes noted in the qualitative analysis, the one clinic that had previously provided only store and forward services for radiology has discontinued their services altogether. For the three clinics that did multiple forms of telehealth technology, the interviewed personnel focused on the form of technology that was primarily used in the clinic, which was live video. However, the themes that did emerge for each mode of telehealth technology could be linked back to the barriers that were found in the quantitative analysis.

End-user comfort was significantly associated with live video telehealth services in Nebraska clinics. From our thematic analysis, we found three themes related to the

comfort of use by both the providers and patients. Patients were reported to really enjoy the use of technology and to be accepting and satisfied with telehealth consultations. Many of the clinicians attributed this satisfaction and even the request of telehealth over in-person visits, due to less wait time and less travel time for patients' appointments. Comfort with using the technology usually took no more than one or two sessions for the patient to feel at ease. Some clinics also supported patients with staff in the room to help in case of confusion.

On the other hand, many clinic staff saw physician perceptions of the technology as a barrier. Physicians resisted the change in the traditional norms of medicine and their daily workflow. This is in conflict with the results of the multivariate analysis which found an association with having a greater proportion of MDs to increase the likelihood of store and forward technology. This does not mean that either the qualitative or the quantitative results are incorrect, we know that the clinics doing store and forward that had interviewed personnel provided several forms of services. Store and forward is often done by radiology departments, and the positive association with the proportion of MDs could be true for those clinics that specialize in radiology but were unable to be contacted for an interview.

Most clinic staff discussed some of the characteristics of their patient population, however, not usually in the proportion of insurance coverage. Interviewed personnel discussed the age range of patients, two clinics saw a majority of senior patients and would, therefore, see many patients with Medicare insurance. Most of the clinics provided services in several areas of their practice, which meant that they saw patients from a diverse age range. When insurance forms were discussed by the clinic managers

and telehealth coordinators, they were discussing what telehealth services would be covered by the insurance. Reimbursement barriers were predominantly associated with S&F and RPM telehealth technologies in the survey data. Reimbursement in the qualitative analysis seemed to be less related to the form of technology but the direction of telehealth services. If the clinic provided telehealth services to other clinics, such as larger urban clinics networking to more rural areas, there seemed to be a greater issue with reimbursement. This may be due to the grants that were used to purchase the equipment in many of the rural clinics, and the bundled payments that can be used to cover the telehealth services provided on the receiving end. Those providing the physician and specialty services have the task of coding properly for reimbursement and the need to gain reimbursement to cover the cost of the physician's time and the use of the equipment.

III. Discussion:

The aim of the quantitative portion of this study was to assess the types of technology Nebraska clinics are utilizing and to analyze the different barriers that were perceived by providers using diverse forms of telehealth technology. Some variables that were controlled for and tested by chi-square and logistic regression testing were relevant to the structure of the organization. This included the proportion of MDs working in the clinic, patient insurance status, and the average age of the healthcare providers. Although these are not noted as specific "barriers" in the survey, based on prior literature review, these factors can have an effect on the implementation and subsequent use of telehealth technologies. [1,2,6,11,17]

The qualitative arm of the study was derived from the inferences gained from the quantitative results. These results informed the participant sampling and synthesis of interview questions. Themes from the qualitative portion were able to be linked back to the quantitative results in an integrated joint display, highlighting the main areas of this study. The majority of the clinics doing telehealth were using live video to provide services to their patients. Implementation barriers were positively associated with using live video technology, such as licensing of provider issues and comfort with using the technology in the quantitative analysis. Qualitative analysis tended toward greater issues with the comfort of use on the provider side of the technology. Providers were perceived to lack ambition to take the time to learn about the benefits the technology can have for the clinic and resisted the change to the traditional medical practice workflow. Two of the larger urban providers of telehealth services across state lines noted the interstate licensing compact and the benefit compacts could have on easing the licensing process for physicians.

Cost of implementation and maintaining technology was marginally significant in decreasing the odds of live video use. This relates back to the lack of clinics being ready, willing, and potentially able to adopt this technology. If the benefit for patients, providers, or the clinics' financial situation is not seen, there is neither the readiness nor willingness to adopt. Also, if cost is an issue due to lack of resources, this relates to the clinic's ability to implement live video technology. The clinic personnel that were spoken with during interviews did not see cost as a barrier, many receiving grant money to purchase the clinic's equipment and get telehealth programs started. Only one clinic noted that cost was an issue for their clinic. For a predominantly rural state like Nebraska,

lack of funds to get programs started and lack of networking facilities could be a major issue in the expansion of telehealth services to rural communities lacking access to specialists.

There was some association with the ability to perform at least one-way telecommunication between providers and increased use of live video. Comfort of use and other technology used in the practice can be linked. If other technology is being used, it can increase the comfort of use for providers and patients of the clinic, it can also provide legitimization of the benefits of using technology within a practice. As noted in the results, many clinics were doing multiple forms of telehealth services. Similarly, they were using EHRs to exchange medical information between providers and utilizing their live video technology for staff education. Having the infrastructure already within the system structure can help the preconditions of readiness, willingness, and the ability of an organization to be met. For example, live video technology that already fits into practice workflows and has been proven beneficial for the clinic will make the transition of additional telehealth technology less disruptive.

The technology already in use can also provide a way of easily implementing new technology as the equipment and server requirements may already be in place, reducing upfront costs. This increases the readiness and willingness of staff to take on more forms of technology when able, as there is a comfort with and knowledge of technology use. For example, "*I think once we got it implemented everything's gone well, and that's been a positive for us, because once we did the geriatric program, got that implemented and that went well, then, it was easier to convince people that we should use this other program through Bryan too.*" However, if the experience is unpleasant, such as in the

case of the teleradiology clinic that ceased services due to poor response rates of providers and increased personnel workload, the clinic will not be ready or willing to try similar technology. Although the manager stated that the prices of the service were reasonable, after the experience they have no intention of using a service such as that again.

Store and forward, as well as, RPM technology have perceived barriers that occur at later stages of use than live video. The odds of using S&F are higher when the clinic perceives medical coding to be a barrier. After the S&F system is in place, the clinic may run into administrative problems when determining how to code for S&F technology. As noted in the results, Nebraska Medicaid will only pay for teleradiology.[17] There are specific codes for telehealth services that differ from the same procedures done in-person. The codes that are reimbursable may also differ by the insurance provider, making it a new maze of coding for the administrative and billing departments of clinics. Although many of the staff doing live video were unaware of potential reimbursement issues, an urban clinic providing all three forms of telehealth services noted problems with coding, needing to recode, and that there are often "*extra hoops to go through*" to obtain reimbursement.

RPM technology showed significant increases in odds of use when medical coding, claims denial, and reimbursement rates were perceived as barriers. Once the RPM technology is in place and reimbursement is sought, the few clinics that are using RPM to provide services run into issues with improper coding leading to claims denial and if they manage to code correctly, they did not see parity in payment. Nebraska Medicaid does pay for RPM in certain cases and provides a daily per diem-rate.[17] Until

January of 2018, Medicare did not cover any RPM services.[116] In the logistic analysis for RPM the greater proportion of Medicaid patients seen by the clinic increased the use of RPM technology; this may be explained by the qualitative interviews. Many of the facilities are charging via bundled payment when possible or only charging room fees, which are unrelated to the telehealth services.

One of the facilities who did more RPM was frustrated with the fact that RPM provided in the home is still not reimbursable by Medicaid and many other insurers. This was also true for Medicare until January of 2018 when CMS unbundled RPM from other services.[116] RPM is not considered a telehealth service but is coded as an administrative time component for providers. If the time a provider takes to receive and analyze data remotely is more than 30 minutes, the provider can bill for the service.[116] Although this is a step forward, it is only applicable to those monitoring devices that connect to the provider and can deliver data live. This code can also be used only once per patient every 30 days and only once per patient during a chronic care management, transitional care management and behavioral health integration service period. [116] So despite the ability to code for RPM provided within the patient's home, there is still a limit on the amount that can be recouped for these services.

With the introduction of the barrier of networking with multiple sites in the qualitative arm of the study, more important factors about the standardization of telehealth services arose. The clinics providing services noted the importance of planning and design when creating telehealth programs. One clinic manager stated, *"Support is huge when you are implementing anything new. There's so many things to consider like design, your type of solution, whether it's a fixed solution, a desktop, or a cart that needs*

a connection to other equipment and that list goes on and on and on. Then you have your infrastructure, your room configuration, camera placement, designated area, your backdrop, you know, paint choice, lighting, power, all of those things that you don't really think about until you get into it. And so, support on every level is huge." Another telehealth coordinator when asked "how they chose to use a form of technology?" had a similar response, noting the need to determine the clinic's need and capability for technology. There is no set way to measure the success of a telehealth program, there is no standard way to reimburse for the services, and there is no definitive network requirement to incentivize providers to link together and expand access to care. With the knowledge gained from this study more can be done to address the gaps in standardizing the exchange of information and networking communities in need with available providers.

Limitations

The HPTS data that was analyzed was limited in size by the return rate of multiple surveys. Proportions of MDs and average age were limited by the providers that responded to the survey, and may not be representative of the whole clinic population. However, providers were verified within the clinic survey as providers of that site which helped to provide verification on the number of providers and types of providers in the locations. The cell sizes were small for RPM and S&F which limited the scalability of the data and its generalizability. This led to fewer categories for many of the independent variables and limited the detail that can be assessed in these analyses. Despite these limitations, the data was used appropriately for the purpose of setting the foundation for the qualitative portion of the study. The data provided the clinic information needed to

contact facilities and set a base for the types of barriers that were most frequently associated with telehealth technology in Nebraska. The types of technology being used and the barriers associated were then used to form interview questions that could expand the understanding of telehealth in Nebraska.

The sampling for the qualitative arm was small, with only 14 interviews. The greatest effort was put forth to diversify the sample of clinics selected for interviewing. However, it has been a year since the completion of the survey, and several clinics have added services, one has yet to "go live" with their proposed telehealth program that was noted in the survey, and another clinic has ceased their telehealth services completely. Diversification was gained in location and rurality, but less with the form of telehealth technology. Despite this setback, diversity was gained by engaging with the staff of organizations at different stages of telehealth use and speaking with clinics that both provided telehealth services and those that predominantly received telehealth services.

IV. Conclusion

The providers of telehealth services in Nebraska clinics see an expanding future for telehealth in the state. Yet there are still many barriers to utilizing telehealth technologies to their maximum benefit. Clinics still need assistance to cover the costs of telehealth equipment and set up especially small rural clinics. Policy changes that allow for reimbursement of services in all formats and within the patient's home are still not at a level that many providers would like them to be. The barrier of standardization of networks between sites is another insight from this study that will need to be researched further and potential solutions determined; in an effort to connect communities in need with necessary providers and to make the process of connecting and communicating

between providers go as smoothly as possible yielding better patient outcomes and care management.

Chapter 5: The Effect of Telehealth Interventions on Cancer Patients and Cancer Survivors' Quality of Life: Systematic Reviews and Meta-Analyses.

A. Cancer Patients Undergoing Treatment: A Systematic Review and Meta-Analysis[1]

I. Introduction

Nearly two million new cases of cancer are diagnosed every year in the United States.[117] Cancer patients can experience multiple issues during treatment, including physical, functional, and psychosocial symptoms and complications.[19,23,118–121] Cancer diagnoses can lead to severe psychological distress and disrupt patients' lives, increasing strains on work, family, and social relationships.[118,122,123] Improved management of emotional distress and symptoms, especially after new diagnoses and treatments, could significantly improve quality of life for cancer patients.[20] Furthermore, the need for effective and cost-efficient interventions to address psychosocial symptoms resulting from treatment will increase in the future with the aging demographic distribution in the US and the consequent increase in cancer diagnoses.[124]

Telehealth has been effectively used to help manage many chronic conditions and to improve compliance with treatment and patients' overall well-being.[119] The terms 'telehealth' or 'telemedicine' are often used interchangeably and can have multiple definitions. Telemedicine is often used to refer to diagnosis and monitoring technology,

[1] The material presented in this Chapter Section A was previously published: Larson JL, Rosen AB, Wilson FA. The Effect of Telehealth Interventions on Quality of Life of Cancer Patients: A Systematic Review and Meta-Analysis. 2018;24(6):1-9. doi:10.1089/tmj.2017.0112.

whereas telehealth may be used to include management, education, and other allied health care services.[109] The Health Resources and Services Administration defines telehealth as the use of technology to deliver health care, health information, or health education at a distance.[18] Telehealth technologies, including telephone, videoconferencing, and internet-based interventions, have the capability of bringing services into the patient's home and helping them manage their symptoms without needing to be physically present at a hospital or clinic.[19,20] Telemedicine patients have reported good acceptance of and satisfaction with the use of technology in comparison with in-person visits.[25,125] Providing patients greater access to symptom management and emotional support services may lead to patients taking a more active role in their healthcare and could improve patient outcomes including overall quality of life (QOL).[19]

The purpose of this systematic review and meta-analysis is to examine the effect that telehealth interventions providing emotional and symptom management have on cancer patients' quality of life (QOL). To our knowledge, there has been no study done to date that has examined the overall effect of supporting patients in the management of their symptoms via telehealth technology in comparison to in-person usual care (UC). We determine whether interventions utilizing telehealth-delivered support are more effective in improving QOL versus UC from baseline until the end of the intervention period.

II. Methods

The recommendations outlined in the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement were used to guide this systematic review and meta-analysis.[126]

An electronic database search was initially conducted from inception to December 31, 2016 by two of the coauthors using the following databases: National Library of Medicine Catalog (Medline/PubMed), SCOPUS, the Cumulative Index for Nursing and Allied Health Literature (CINAHL), Ebsco Health (Medline complete). The initial key-term search consisted of: "telehealth OR telemedicine" AND "Cancer" AND "quality of life OR assessment". After the initial search, article titles and abstracts were inspected for relevance with the inclusion and exclusion criteria, followed by obtaining full-texts for identified manuscripts. Manuscripts were then further scrutinized for inclusion and exclusion criteria post-retrieval. Reference lists of full-text manuscripts were then hand-searched and cross-referenced for potentially applicable papers. Another separate search on the Cochrane Library was conducted for systematic reviews containing similar content. Pertinent systematic reviews were then obtained and cross-referenced for additional manuscripts missed during the original search. A consensus among all the authors was then sought for an article's final inclusion in the meta-analysis.

All manuscripts included in the systematic review and meta-analysis must have been published in a peer-reviewed journal and met the following inclusion criteria: 1) Patients included must have had any form of cancer and be undergoing active treatment; 2) Patients must have been adults, 18 years of age or older; 3) Interventions must have used some form of telehealth/telemedicine, including but not limited to telephone calls and/or web-based interventions; 4) The focus of each intervention must have been on emotional support or self-management of symptoms through counseling, educational intervention or telepsychiatry; and 5) Studies must have used a measurable quality of life (QOL) scale or questionnaire. Studies were excluded if they: 1) Were written in a

language other than English; 2) Included pediatric patients; 3) If they assessed the efficacy of palliative care; or 4) Combined in-person and telehealth in the same intervention.

For the systematic review portion of this study, descriptive data were extracted from each of the included articles pertaining to their methodology and results. Numerical data extracted for the meta-analysis included sample sizes, QOL measures means and standard deviations from baseline and post-intervention as well as effect sizes for each study whenever data were available. If effect size results were not reported, they were conservatively estimated based on the obtainable data from each included study. Once the study data was obtained, standardized mean differences between baseline and post-test while adjusting for small sample bias (Hedges g) were calculated for telehealth interventions and usual care (UC) separately[127]. A mean effect size (Δ) for both telemedicine and UC was determined using a random effects model due to the uncertainty of evaluating a homogenous population.[128]

Heterogeneity was assessed via I^2 and Q-statistics. To gauge the impact of bias from unpublished studies on the mean effect size, the fail-safe N was also evaluated.[128] All effect-size data and heterogeneity statistics were calculated with the Comprehensive Meta-Analysis software package.[129] Effect size data were interpreted as 0.1-0.3=small, 0.3-0.5=moderate and >0.5= large effects. [130] After effect size calculations were acquired, independent *t*-tests were then used to determine if differences existed between the effect sizes of the telemedicine and UC cancer delivery interventions utilizing the IBM Statistical Package for the Social Sciences (SPSS) software.[131] The significance level was set to $p<.05$ for all statistical analyses a-priori.

III. Results

Figure 5.1: Article Selection Flow Diagram and Number of Articles Reviewed

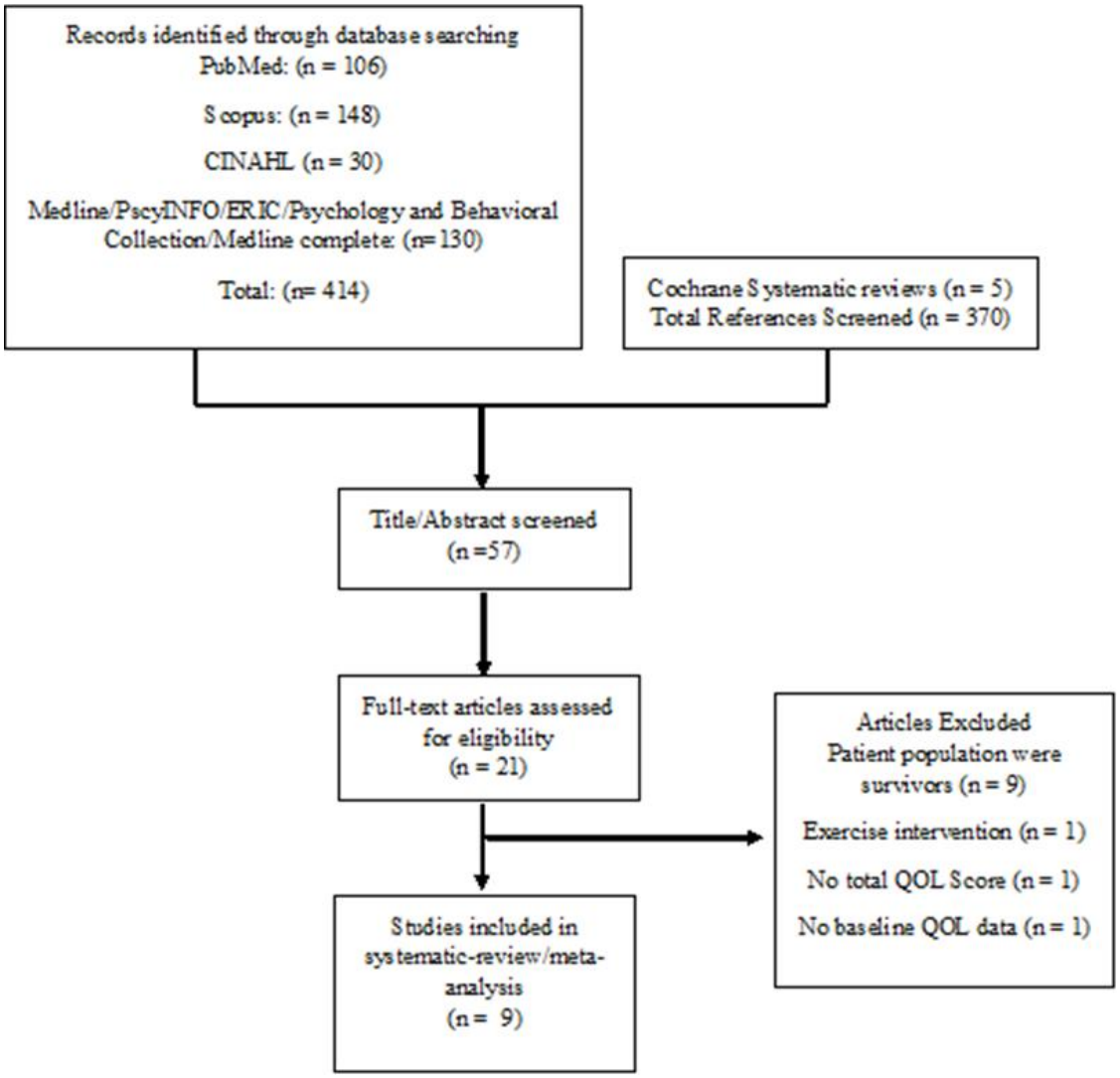


Figure 5.1 is a flow diagram of our article selection process. Our initial search for articles using our search terms within the designated literature databases yielded a total of 414 articles. A search in the Cochrane database for systematic reviews containing similar

content provided 5 systematic reviews, and all the references within the systematic reviews, totaling 370 article titles, were screened. After titles and abstracts were screened, 57 articles were retained to be assessed by two authors to ensure consensus on inclusion. After duplicates and those that did not fit the inclusion criteria were excluded, full-text assessments were performed on the 21 remaining articles. Nine articles were excluded due to the patient population being cancer survivors and not in active treatment, and one article was excluded because the intervention was exercise-based. Nine articles (Table 5.1) ultimately fit all systematic review and meta-analysis criteria.

Table 5.1. Summary of Evidence for Each Individual Study Included Resulting from Systematic Search of the Literature

Author (Year)	Participants	Inclusion Criteria	Intervention Type	Outcome Measure	QOL Baseline	QOL End	Results of study
Berry, Hong, Halpenny, Partridge, Fann, Wolpin, Lober, Bush, Parvatheneni, Back, Amtmann, & Ford (2014)	Control= 292 Intervention = 289	Diagnosis of cancer, ambulatory, age ≥18 years, starting a new therapeutic regimen and spoke/read English.	Electronic Self-Report Assessment-Cancer (note book or home computer).	Baseline, 3 to 6 weeks after starting treatment, 2 weeks after last assessment and 2 to 4 weeks after intervention: SDS-15	Control = Mean 24.1 SD 6.8 Intervention = Mean 24.3 SD 6.7	Control = Mean 25.4 SD 7.9 Intervention = Mean 24.2 SD 6.7	Intervention group had lower starting distress, age was a factor in the improvement in QOL. Those that were older and higher distress saw the most improvement.
Chumbler, Mkanta, Richardson, Harris, Darkins, Kobb, &	34 Patients	Veterans with a new diagnosis of cancer. Treatment plan included	Home Messaging Device (Health Buddy)	Baseline and after each chemotherapy cycle was completed	Baseline: 73.9	6-Month: 78.4	Patients experienced a significant increase in HRQL over the

Ryan (2007)[a]		chemotherapy at a single Department of Veterans Affairs Medical Center (VAMC). Life expectancy of >6 months, no severe sensory impairment, psychosis or diagnosis of dementia or traumatic brain injury, non-institutionalized and have a landline telephone.		(3 months and 6 months): FACT-G			six-month treatment period.
Harrison, Young, Solomon, Butow, & Secomb (2011)	Control = 36 Intervention = 37	Over 18 years of age, admitted for surgery for colorectal cancer (any stage) and has telephone access.	CONNECT telephone intervention, emotional support and dealing with patient unmet needs.	Baseline, 1 month, 3 months and 6 months: FACT-C	Control = Mean 86.6 SD 19.5 Intervention = Mean 88.1 SD 20.9	Control = Mean 98.6 SD 23.4 Intervention = Mean 106.0 SD 19.3	At 6 months, total quality-of-life scores were higher for intervention group patients than controls, though not statistically significant. QOL improvements were more than twice as large and clinically significant

							in the intervention compared with the control group.
Hegel, Lyons, Hull, Kaufman, Urquhart, Li, & Ahles (2011)	Control = 16 Intervention = 15	Living Well trial, female breast cancer patients (Stage 1-3) undergoing chemotherapy. 18 years of age or older.	Problem solving and occupational therapy intervention delivered over the phone, control was usual care	Baseline, 6 weeks and 12 weeks: FACT-B	Control = Mean 109.66 Intervention = Mean 99.1	Control = Mean 111.9 Intervention = Mean 105.58	Not statistically significant but intervention group had greater improvement after adjusting for baseline QOL.
Pfeifer, Keeney, Bumpous, Schapmire, Studts, Myers, & Head (2015)	Control = 35 Intervention = 45	Initial diagnosis of head or neck cancer and involved in a treatment plan. Capacity to give informed consent and can speak, read and comprehend English on a 6th grade level or above.	Health Buddy, connected to landline to answer symptom questions and receive symptom management support.	Baseline, midpoint of treatment (3 weeks) and posttreatment (6 weeks): FACT-G and FACT-HN*	Control = Mean 98.81 Intervention = Mean 100.25	Control = Mean 89.86 Intervention = Mean 101.53	Intervention group had significantly better QOL scores for some subscales but not for overall QOL score.
Ruland, Andersen, Heneson, Moore, Grimsbø, Børøsund, & Ellison (2013)	Control = 135 Intervention = 110	Diagnosed with breast cancer or prostate cancer and undergoing treatment. 18 years and older, internet access at home, no	WebChoice, interactive health communication application,	Baseline and 12 months =Quality of Life 15D	NR** Only slope and p-values were reported.	NR** Only slope and p-values were reported.	Both groups had negative slopes from baseline to 12 months. No significant

		radiation on the brain.					difference between control and intervention group for QOL measure.
Ryhänen, Rankinen, Siekkinen, Saarinen, Korvenranta, & Leino-Kilpi (2012)	Control = 43 Intervention = 47	Newly diagnosed breast cancer patients who used the internet, and utilized Finnish University Hospital.	Breast Cancer Patient Pathway, Internet based patient educational program.	Baseline at diagnosis, multiple times during treatment and 1 year after diagnosis: Quality of Life Instrument-Breast Cancer Patient Version	Control = Mean 6.36 SD 1.36 Intervention = Mean 6.07 SD 1.31	Control = Mean 6.57 SD 1.60 Intervention = Mean 6.50 SD 1.42	No significant differences were found between the two groups.
Sandgren & McCaul (2003)	Control = 55 Intervention (HE) = 78	Diagnosis of breast cancer (Stage 1-3), ability to speak English and talk by phone, absence of serious comorbid conditions and undergoing treatment.	Telephone health education program, emotional relief and improved self-efficacy.	Baseline and 5 months: FACT-B	Control = Mean 112.95 SD 21.44 Intervention = Mean 113.03 SD 18.68	Control = Mean 117.96 SD 16.51 Intervention = Mean 117.96 SD 19.30	The health education group saw an improvement in QOL but it was not statistically significant compared to the control group.
Shepherd, Goldstein, Whitford, Thewes, Brummell, & Hicks (2006)[b]	25 patients	Adult cancer patients at regional treatment centers in the New England area of New South	Videoconference, psychological intervention.	Pre-treatment, post-treatment, & one month follow up: FACT-G	Mean =53.92 SD = 4.32	Mean = 56.76 SD = 6.77	Statistically Significant increase in QOL (p=.04), particularly in emotional (p=.003)

		Wales, Australia. Refered by provider or tested with Distress Thermometer.					and functional areas (p=.02).

RCT, Randomized Control Trial; QOL, Quality of Life; SD, Standard Deviation
*Used FACT-HN for meta-analysis.
**NR-Not Reported
[a] Feasibility Study
[b] Pilot Study

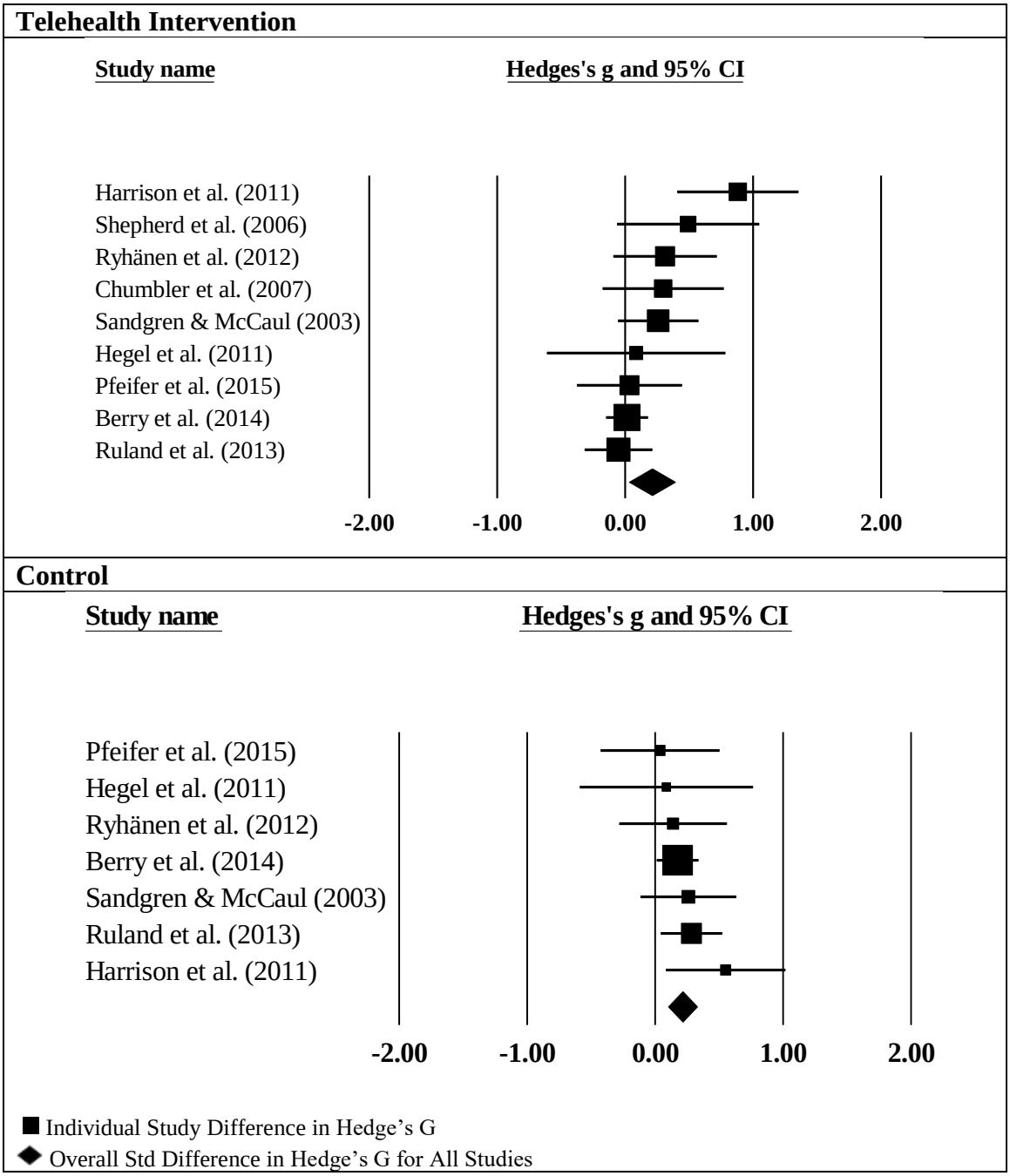
Five out of nine articles used telephone-based interventions (56%), another three studies used web-based designs or connected devices (33%) and one (11%) utilized videoconferencing. The time period for the studies varied, ranging from 6 weeks to one year. One article did not specifically report the time period from baseline to final assessment, but stated it was one month after treatment.[132] The mean age of the patients within the 9 articles ranged from 53 to 67 years of age. Five of the articles focused on specific cancers, e.g., colorectal, breast, and head and neck cancers,[23,29,133–135] whereas three articles included three or more types of cancer within their study population.[132,136,137] Pfeifer et al. (2015) included both breast and prostate cancer patients.[138]

Of the nine articles included, only one had statistically significant results for overall QOL scores from baseline to end of the study period and did not have a comparable control group. [132] Two articles did find clinically significant improvements in the intervention effect on QOL but were not statistically significant. Berry et al. (2014) did not find statistically significant between-group changes in QOL overall but did report statistical significance for a sub-analysis by age. There was a statistically significant intervention effect for those ≥50 years of age, though not for those younger.[137] Hegel et

al. (2011) found statistically significant improvements for the intervention group compared to the usual care control for overall QOL as well as emotional and social well-being subscales at 6 weeks. However, after the intervention was completed, the 12-week end of study QOL scores were not statistically significant between groups.[29] A similar effect was found in Pfeifer's (2015) study, as there was no statistically significant difference between groups in the overall QOL score, although there were statistically significant differences in physical well-being after the intervention.[138]

The Ruland (2013) and Rhyanen (2013) studies reported no statistically significant between-group results for the telehealth intervention on QOL. Both studies did find other statistically significant results related to lower anxiety and depression scale scores for those in the intervention groups compared to the usual care controls over the study period.[134,135] Ruland et al. (2013) found that the intervention group had significant decreases in depression scale scores and did not have the significant decreases that were found over time in the control group for QOL and self-efficacy scores.[134] Rhyanen et al. (2013) collected data more frequently and were able to associate QOL changes with events such as increases in QOL after surgery and decreases in QOL at the end of radiotherapy [135] The intervention group had a continual decrease in anxiety over time, whereas the control group had greater anxiety before surgery and chemotherapy, as well as during chemotherapy treatments.[135] In the study, anxiety was statistically significantly associated with overall QOL scores and physical, psychological, and spiritual well-being subscales.[135]

Figure 5.2: Forrest Plots of Hedges g and 95% Confidence Interval by Name of Study



In total, 16 individual effect sizes—nine for telehealth interventions and seven for UC—were calculated. Across the nine studies included in the meta-analysis, 680 patients

received telehealth cancer interventions, while 602 patients received UC. The distribution for all unweighted effect sizes calculated are displayed on a forest plot in Figure 5.2. The summary statistics for the mean effect sizes for telehealth and UC with their 95% confidence intervals, heterogeneity statistics and fail-safe N calculations are reported in Table 5.2.

Table 5.2. Summary Statistics for Telemedicine Intervention and Usual Care Across All Included Studies

Intervention	*n*	Mean Δ (95% CI)	*p*	*Q*	I^2	Fail-safe n
Telemedicine Intervention*	9	.211 (0.033, 0.390)	0.016	8.45	4.93	17.0
Usual Care*	7	.217 (0.105, 0.329)	<0.001	3.41	0.0	16.0

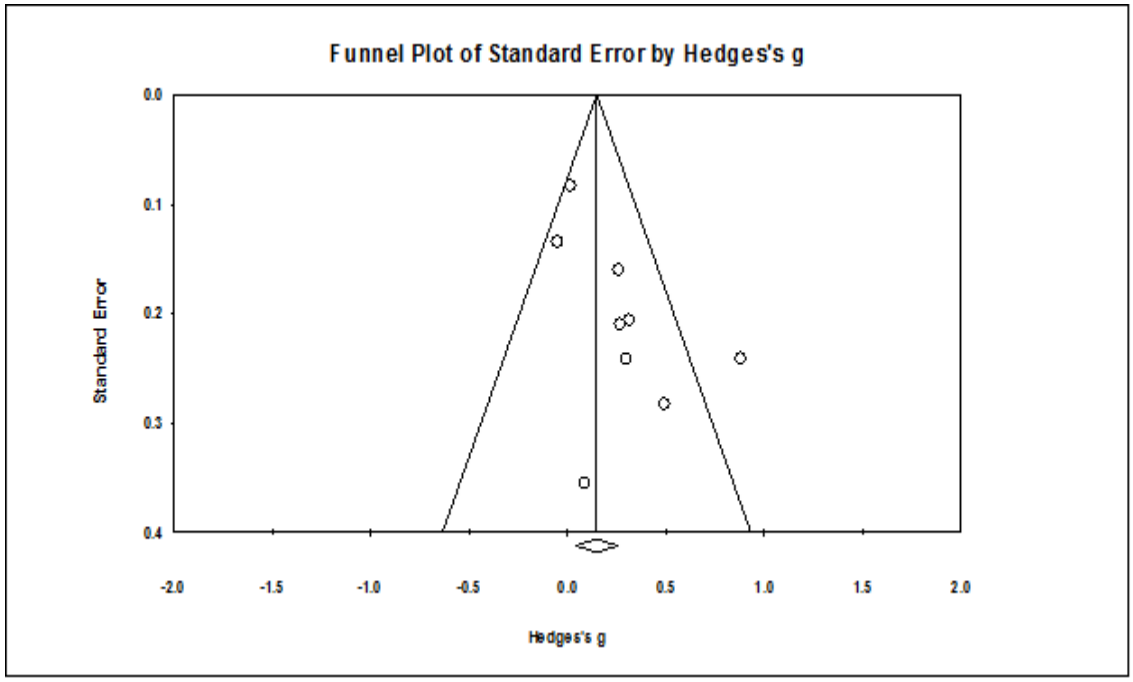
*Indicates significant mean effect size (p<.05) relative to baseline.
CI: Confidence Interval

Both telehealth (**Δ** = 0.211, p=0.016) and UC (**Δ** = 0.217, p<0.001) demonstrated small but statistically significant mean effects compared to baseline QOL across the included studies. They each had relatively low Q and I^2 values indicating homogeneity across the included studies (Table 5.2). No statistically significant differences were present between the mean effect sizes of telehealth and UC interventions (t= -0.31, p=0.76).

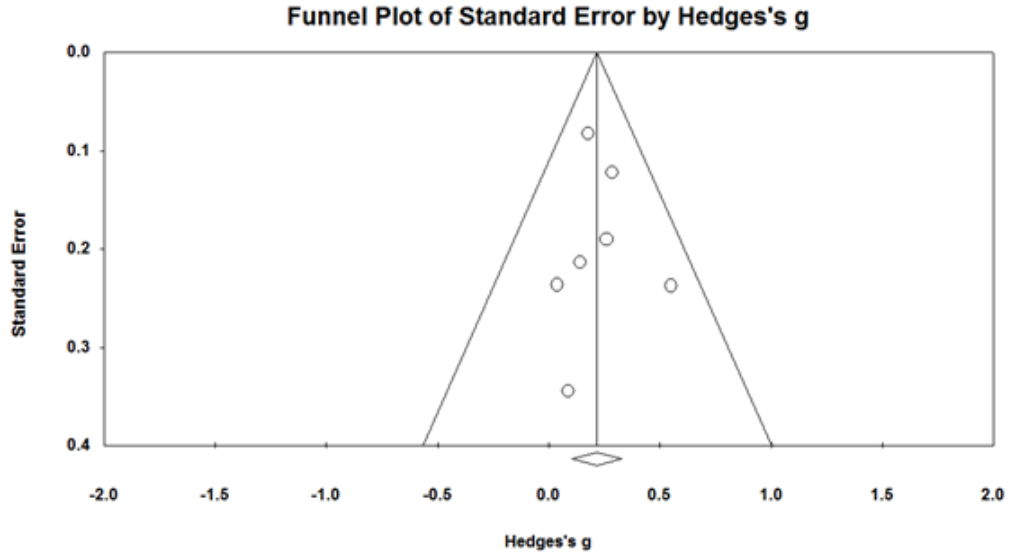
Figure 5.3 shows the different funnel plots for homogeneity for the telehealth intervention studies and the usual care control articles.

Figure 5.3: Funnel Plot for Telehealth Intervention and Usual Care

Telehealth Intervention



Usual Care



Sensitivity analysis was performed by revising the meta-analysis to include only those articles that used the FACT scale for quality of life. Including only these six studies increased the effect size of the intervention group (**Δ** = 0.338, *p*=0.006), and the effect size was still statistically significant. The control group in this analysis had a smaller increase in effect size (**Δ** = 0.256, *p*=0.013). This suggests that using different scales for measuring QOL may affect the measurable impact of the telehealth interventions. We also stratified the meta-analysis to compare telephone interventions (n=5) versus internet/device interventions (n=4). This resulted in telephone interventions having a larger effect size (**Δ=**0.325, *p=0.028)* than the internet/device interventions (**Δ=**0.092, *p=0.341)*. Thus, our findings suggest that the type of telehealth modality affects the potential benefits of telehealth for cancer patients.

IV. Discussion

Our study performed a systematic review of peer-reviewed studies that utilized telehealth interventions to improve emotional support and symptom self-management for patients receiving treatment for cancer. Our findings demonstrated a statistically significant, albeit small increase in QOL for the telehealth intervention group relative to baseline across the nine studies in the meta-analysis. The UC group had a similar, statistically significant improvement across seven studies, but we found telehealth to be non-inferior to UC in improving quality of life for cancer patients. Sensitivity analysis suggested that telephone-based interventions may be superior to internet/device interventions for cancer patients.

The studies in our meta-analysis and systematic review were relatively homogenous as demonstrated by funnel plots (Figure 5.3). Harrison et al. (2011) was the

only potential outlier showing significantly improved effectiveness of telehealth versus UC; however, this was the only study analyzing patients with colorectal cancer.[133] It is possible that telehealth-based psychosocial treatments would vary in effectiveness across cancer diagnoses. Unfortunately, there has been insufficient research to demonstrate this. [21]

Our findings are consistent with prior research demonstrating non-inferiority of telepsychiatry interventions versus face-to-face treatment. [139–141] Thus, by maintaining a comparable QOL while averting the need to travel for in-person therapy or treatment, the use of telehealth for psychosocial support of cancer patients is likely to be cost-effective. Furthermore, telehealth may be effective in improving outcomes other than QOL, however, such as patient satisfaction and acceptability of the new modality. [24] For example, a systematic review conducted by Calvin et al. suggested that most patients accept and are satisfied with many forms of telehealth interventions they received.[142] Another study showed that telehealth did not lead to lower patient satisfaction in communicating with their providers. [32]

Our inclusion criteria stated that all articles must have an overall quality of life measurement. Of the nine studies in our systematic review, the majority (67%) used the Functional Assessment of Cancer Therapy (FACT) QOL instrument—either the general or cancer-specific FACT instrument—as shown in Table 5.1. The general FACT scale was developed and validated between 1987 and 1992, in a five-phase process, including item generation, item review and reduction, scale construction and piloting, initial evaluation, and additional evaluation.[143] FACT-G is a 27-item instrument that has subscale scores for physical, functional, social, emotional well-being and satisfaction

with treatment.[143] Cancer-specific FACT scales include those questions that are in the FACT-G but have additional questions that are cancer specific, such as for colorectal cancer (FACT-C), breast cancer (FACT-B), and head and neck cancer (FACT-HN).[144–147] Berry et al.(2014) used the Symptom Distress Scale (SDS), which has 15 items—the 13 included in the usual SDS instrument and an additional 2 questions related to sexual activity and interest and fever and chills.[137] The SDS used a 5-point Likert scale ranging from no distress or normal (0) to severe distress (5), creating a total SDS score from an unweighted summation of the scores.[148] Ruland et al. (2013) also used a 15-dimensional self-administered instrument for measuring QOL based on similar symptoms to the SDS, but using a 5-point Likert score where higher scores denoted improved health status.[134] [149] The breast cancer version of the Quality of Life Instrument was used by Ryhanen and colleagues.[135] Their instrument has 46 items grouped into four subscales related to physical, psychological, social and spiritual well-being. A 10-point Likert scale is used with 0 indicating the worst outcome and 10 the best outcome. An overall QOL score is created by summing the subscale variables and calculating the mean values.[150]

Although our focus was on the improvement in the quality of life of cancer patients who received a telehealth intervention for emotional or symptom management support, it is important to note that telehealth increases access to care for cancer patients, as well as for those suffering from other chronic conditions. Rural patients are at higher risk for decreased access to specialized care, and telehealth has been found as a way to increase access to quality care. Telehealth can ease the burden of travel time, cost, and the discomfort that may be associated with long travel times.[151,152] Telehealth can also

overcome issues related to ethnicity, culture, and language that affect health, by facilitating access to culturally competent providers and interpreters.[152]

Our study should be interpreted in the context of certain limitations. Our meta-analysis had a small sample size of manuscripts and patient pools, and thus we were unable to perform a moderator analysis to determine if alternative factors influenced the effectiveness of treatment delivery. On a similar note, different cancers, stage of cancer and treatment protocols may have varying impacts on QOL, which we were unable to explore due to the limited number of studies. [153–155] A study on the factors affecting the quality of life of cancer patients undergoing chemotherapy found worse quality of life in breast cancer, head and neck, sarcoma, lung and gynecological cancers. Colorectal cancer patients were found to have the better quality of life. [156] Lower quality of life in breast cancer patients may be due to changes in self-image due to surgery and hair loss, as well as decreased sexual function and early menopause. Similarly, head and neck cancers and sarcomas surgical treatment can lead to disfigurement and cause lower quality of life for patients.[156] In addition, we were unable to effectively assess manuscript quality as part of our analysis as there was a range of study designs included. Due to the low sample, we chose to include all studies relevant to our inclusion criteria and agreed upon by author consensus, regardless of design. Because of inconsistent and limited published data, we erred on the conservative side when necessary during effect size calculations; this only occurred for two studies, Pfeifer et al. (2015) and Hegel et al. (2011). [29,138]

V. Conclusions

Our systematic-review with meta-analysis demonstrated that supplementary interventions through telehealth have a comparable impact on quality of life scores

relative to in-person usual care. Utilizing telehealth may allow clinicians and healthcare systems to increase access for those cancer patients who lack the means to travel for additional treatment or are rurally located creating increase travel costs and time. Some of the studies in this meta-analysis did see improvements in other areas such as depression, anxiety, and emotional, social, and physical well-being, even when overall quality of life was not statistically significantly improved. Our findings suggest more studies need to be conducted on the impact of telehealth interventions across different cancer diagnoses in order to gain better insight into the differential effect these interventions may have on the quality of life for cancer patients undergoing treatment.

B. Cancer Survivors: A Systematic Review and Meta-Analysis

I. Introduction

As of January 2016, there were an estimated 15.5 million cancer survivors in the US and, for them, the transition from treatment to aftercare is a difficult process.[157,158] Transition of care requires changes in the patient's self-care, as well as continued coordination of ongoing medical care.[159] Advances in treatment delivery, as well as the increasing proportion of the US population over the age of 65 years, will increase the need for transitioning services and supportive care for cancer survivors.[157,160,161]

The diagnosis and treatment of cancer lead to psychological and physical side effects.[162] In conjunction with physical symptoms, psychological symptoms, such as anxiety and depression can be a challenge for treating clinicians.[28,158,162–164] Depression and anxiety are associated with decreased compliance with treatment, as well as low adherence to guidelines for a healthy diet, nutrition, and physical activity.[161,165] Likewise

cancer survivors suffer from increased nervousness and fear in addition to cognitive and functional impairments, leading to reduced quality of life.[28,159–162] By providing patients with education and healthy lifestyle programs, clinicians can help cancer survivors decrease the uncertainty and physical and psychological distress associated with their disease.[162,165]

Cancer survivors post-treatment continue to have unmet needs, and despite evidence showing benefits from supportive care, referral rates are low.[28,41] Cancer survivors may face significant barriers such as poor health and family responsibilities that prevent travel to centralized healthcare facilities.[21] For rural residents and remote communities, acquiring and retaining adequate workforce is a barrier for accessing health care for many patients. This is not only limited to rural areas but workforce shortage areas in many urban areas.[166] One potential solution for gaining access to specialty care is through the use of telehealth technology.[21,41,163,166,167] Telehealth facilitates transitioning of post-cancer treatment care from hospitals to the home and community and empowers survivors and their families or caregivers to play a more active role in managing their care.[28,41,165,168]

The purpose of this systematic review with meta-analysis was to examine the effect that telehealth interventions providing emotional support or self-management of symptoms have on cancer survivors' quality of life (QOL). This systematic review examined the overall effect of telehealth technology to support cancer survivors in the management of their symptoms in comparison to in-person usual care (UC). We were interested in determining whether interventions utilizing telehealth-delivered support

were more effective in improving QOL versus UC from baseline until the end of the intervention period.

II. Methods

This systematic review and meta-analysis were guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[126]

An electronic database search was conducted from inception to October 31, 2017 by two of the coauthors using the following databases: National Library of Medicine Catalog (Medline/PubMed), SCOPUS, the Cumulative Index for Nursing and Allied Health Literature (CINAHL), Ebsco Health (Medline complete). The initial key-term search consisted of: "telehealth OR telemedicine" AND "Cancer" AND "quality of life OR assessment". After the initial search, article titles and abstracts were inspected for relevance to the inclusion and exclusion criteria, followed by obtaining full-texts for identified manuscripts. Manuscripts were then further inspected for inclusion and exclusion criteria post-retrieval. Reference lists of full-text manuscripts were then hand-searched and cross-referenced for potentially relevant papers. Another separate search on the Cochrane Library was conducted for systematic reviews containing similar content. Relevant systematic reviews were then obtained and cross-referenced for additional manuscripts missed during the original search. A consensus among all the authors was then sought for an article's final inclusion in the meta-analysis.

All manuscripts included in the systematic review and meta-analysis must have been published in a peer-reviewed journal in English and met the following inclusion criteria: 1) Cancer survivors post-initial cancer treatment included must have had any form of cancer and completed initial active treatment; 2) Survivors must have been

adults, 18 years of age or older; 3) Interventions must have used some form of telehealth/telemedicine, including but not limited to telephone calls and/or web-based interventions; 4) The focus of each intervention must have been on emotional support or self-management of symptoms through counseling, educational intervention or tele-rehabilitation; 5) Studies must have used a measurable QOL scale or questionnaire; and 6) Studies used a randomized control trial (RCT) methodology. Studies were excluded if they: 1) Assessed the efficacy of palliative care; 2) The patients were undergoing active cancer treatment or 3) Combined in-person and telehealth in the same intervention.

For the systematic review portion of this study, descriptive data were extracted from each of the included articles pertaining to their methodology and results. The Physiotherapy Evidence Database (PEDro) Scale was used to determine the quality of the articles, based on the reported study protocols and results.[169,170] The PEDro Scale is used for RCT studies to determine internal validity by utilizing a list of 11 methodological components that affect the quality of the methodology.[170] The higher the score, the greater the methodological quality.[169,170]

Numerical data extracted for the meta-analysis included sample sizes, QOL measures means and standard deviations from baseline and post-intervention, as well as effect sizes for each study whenever data were available.

After the collection of study data, standardized mean differences between baseline and post-test for telehealth interventions versus UC were calculated while adjusting for small sample bias (Hedges g).[127] A random effects model was used to determine an overall mean effect size (Δ). The random effects model was utilized due to the uncertainty of evaluating a homogenous population.[128] Heterogeneity was assessed via I^2

and Q-statistics. The fail-safe N was also analyzed to determine the impact of bias from unpublished studies on the mean effect size.[128] All effect-size data and heterogeneity statistics were calculated with the Comprehensive Meta-Analysis software package.[129] Effect size data were interpreted as 0.1-0.3=small, 0.3-0.5=moderate and >0.5=large effects.[130]

III. Results

Figure 5.4: Article Selection Flow Diagram and Number of Articles Reviewed

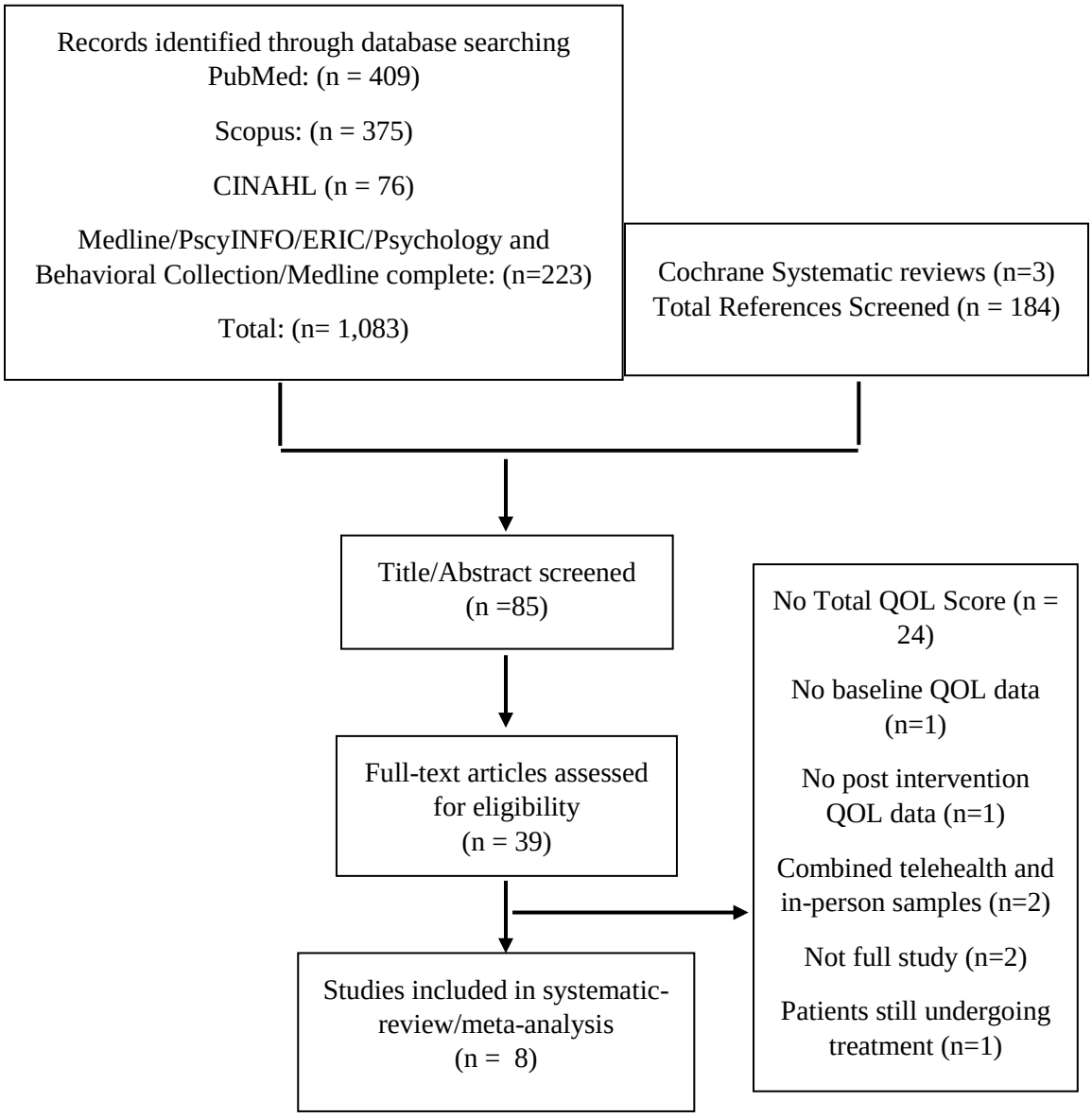


Figure 5.4 is a flow diagram of the article selection process and provides details of the comprehensive search completed as well as the articles included and excluded at each stage. Our initial search for articles using our search terms within the designated literature databases yielded a total of 1,083 articles. Eight articles (Table 5.4) ultimately fit all systematic review and meta-analysis criteria.

Table 5.3. Summary of Evidence for Each Individual Study Included Resulting from Systematic Search of The Literature

Author (Year)	Participants	Inclusion Criteria	Intervention Type	Outcome Measure	QOL Baseline	QOL Post-Intervention	Results of study	PEDro Score
Ashing & Miller (2016)	Intervention = 20 Control = 19	Participants were disease-free women aged ≥18 years who were within 1–6 years after a stage 0–III breast cancer diagnosis and self-identified as African American or Latino.	Telephone Sessions	Baseline and 4-6 months after randomization: Functional Assessment of Cancer Therapy-General (FACT-G)	Intervention = Mean 54.65 SD 5.7 Control = Mean 53.16 SD 2.7	Intervention = Mean 58.2 SD 7.5 Control = Mean 53.89 SD 3.2	Overall QOL significantly increased from baseline to follow-up in the intervention group (p =0.049). In the control group, there was no change in overall QOL from baseline to follow-up.	7
David, Schlenker, Prudlo, & Larbig (2011)	Intervention = 31 Control = 34	Inclusion was not well specified. Breast cancer patients self-selected and registered for the program. The average age was 47 years old with time between diagnosis and registration being 2.2 years, leading to the assumption of survivor status.	Website offered free psycho-social counseling via email.	Baseline and after 2 month intervention completion: EORTC QLQ-C30	Intervention = Mean 52.96 SD 20.81 Control = Mean 50.98 SD 17.26	Intervention = Mean 61.29 SD 20.36 Control = Mean 57.35 SD 20.39	A majority of patients expressed a positive subjective view of the counseling service and regarded it as helpful. However, no statistically significant improvement in QOL for the	6

							intervention group compared to those in the waitlist control group. (p=0.73)	
Freeman, White, Ratcliff, Sutton, Stewart, Palmer, Link, & Cohen (2015)	Live Delivery = 40 Intervention = 19 Control = 43	Confirmed diagnosis of breast cancer, at least 6 weeks after completing treatments, 18 years of age or older, and no major psychiatric illness. Visual and hearing capable, able to read, write, and speak English and demonstrate an orientation to person, place, and time.	'Envision the Rhythms of Life' via videoconferencing software	Baseline, 1-month and 3-months post-treatment: Medical Outcomes Study 36-item short form survey (SF-36)	Live Delivery = Mean 47.2 SD 8.6 Intervention = Mean 46.54 SD 8.48 Control = Mean 45.24 SD 10.23	Live Delivery = Mean 50.54 SD 8.49 Intervention = Mean 46.95 SD 8.04 Control = Mean 45.44 SD 10.24	There was no group effect on the overall QOL measure, however, there was a time effect. The FACT-B scores did improve in the intervention group more than the in-person or control group but was not statistically significant (p = 0.076).	7
Galiano-Castillo, Cantarero-Villanueva, Fernández-Lao, Ariza-García, Díaz-Rodríguez, Del-Moral-Ávila, & Arroyo-Morales (2016)	Intervention = 39 Control = 37	Diagnosis of stage I, II, or IIIA breast cancer, medical clearance for participation, no chronic disease or orthopedic concern that would limit exercise training, access to the Internet, basic computer skills or living with someone with those skills, completed adjuvant therapy except hormone treatment, no cancer recurrence, and signed informed consent.	Internet based telerehabilitation program, e-CUIDATE	Baseline, after the intervention (8 weeks), and follow-up at 6 months after the intervention: EORTC QLQ-C30	Intervention = Mean 59.19 SD 21.01 Control = Mean 54.73 SD 22.53	Intervention = Mean 72.86 SD 19.93 Control = Mean 57.21 SD 21.71	The global health QOL scores improved statistically significantly more in the telerehabilitation group compared to the control group after intervention (p < 0.001)	8

Hawkes, Pakenham, Chambers, Patrao, & Courneya (2014)	Intervention = 159 Control = 163	Persons ≥18 years and resident of Queensland, a histologically confirmed diagnosis of primary colorectal cancer within the previous 12 months and notified to the Queensland Cancer, ability to understand and provide written informed consent in English, no metastatic disease, no medical conditions that would limit adherence to an unsupervised physical activity program (as confirmed by their referring physician), have a telephone, and at least one poor health behavior consistent with the Australian recommendations.	Telephone-delivered health coaching sessions	Baseline, 6, and 12 months: Functional Assessment of Cancer Therapy-Colorectal (FACT-C)	Intervention = Mean 109.8 SD 16.5 Control = Mean 112.7 SD 14.5	Intervention = Mean 115.8 SD 17.4 Control = Mean 116.9 SD 15.4	Both groups showed significant improvements in distress at 6 and 12 months, and there were no differences between the groups. Statistically significant differences in the mean of the treatment group compared to the mean of the control group were observed for cancer-specific quality of life-physical well-being at 6 and 12 months ($p < 0.05$).	7
Malmström, Ivarsson, Klefsgård, Persson, Jakobsson, & Johansson (2016)	Intervention = 26 Control = 23	Underwent oesophagectomy or oesophagogastrectomyfor cancer in the oesophagus or cardia without major postoperative complications that severely prolonged the hospital stay (>6weeks), and with the ability to understand and communicate in Swedish.	Nurse led telephone supportive care program.	2 weeks, 2,4, and 6 months after discharge: EORTC-QLQ-C30	Intervention = Mean 44.5 SD 21.9 Control = Mean 45.3 SD 20.2	Intervention = Mean 65.4 SD 27.8 Control = Mean 64.9 SD 21.8	There was no statistically significant difference between groups for the overall QOL score ($p = 0.698$) The intervention had a statistically significant effect on patient experience,	7

							including satisfaction and access to information to help themselves (p≤0.001).	
Nelson, Wenzel, Osann, Dogan-Ates, Chantana, Reina-Patton, et al. (2008)	Intervention = 17 Control = 19	Patients ascertained from the regional cancer registries with documented histologic diagnoses of squamous cell carcinoma of the uterine cervix, pathologic stage I, II, or III, who had undergone definitive treatment, who were fluent in English or Spanish as their primary language, who had access to a telephone, and who were able to understand and sign an informed consent form.	Psychosocial Telephone Counseling (PTC)	Baseline and 4 months after enrollment, and 2 weeks after the last counseling session for those in the PTC arm: Functional Assessment of Cancer Therapy-Cervical (FACT-Cx)	Intervention = Mean 81.3 SD 3.88 Control = Mean 79.6 SD 2.96	Intervention = Mean 88.5 SD 3.03 Control = Mean 76.9 SD 3.44	The PTC intervention resulted in a statistically significant improvement in QOL within the study population. (p=0.011)	7
Van den Berg, Gielissen, Custers, van der Graaf, Ottevanger, & Prins (2015)	Intervention = 70 Control = 80	Female breast cancer survivors that had a histologically proven malignancy of the breast and completed curative-intent primary treatment 2 to 4 months before the baseline assessment. Understand the Dutch language, access to the Internet, and having an e-mail address.	Breast Cancer E-Health (BREATH) trial, a Web-based self-management intervention	Baseline, after 4, 6, and 10 months: EORTC QLQ-C30	Intervention = Mean 66.79 SD 16.575 Control = Mean 69.79 SD 17.906	Intervention = Mean 72.50 SD 18.572 Control = Mean 70.52 SD 15.231	The intervention did not statistically significantly improve the survivors QOL compared to UC. (p=0.290)	8

EORTC QLQ-C30: European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 items; QOL: Quality of Life; UC: Usual Care; SD: Standard Deviation

Of the eight studies included, five (62.5%) were of breast cancer survivors, one (12.5%) oesophageal cancer survivors, one (12.5%) colorectal cancer survivors and one (12.5%) of cervical cancer survivors. Four of the eight (50%) studies utilized telephone interventions; one (12.5%) a videoconferencing intervention technique, one (12.5%) an email based counseling, one (12.5%) a web-based self-management intervention and one (12.5%) an internet-based tele-rehabilitation program. The length of time from baseline to the end of the intervention assessment ranged 2-12 months, with the majority (5/8) of the articles using six-months or greater as the final assessment. The total patients from these studies were 799 cancer survivors, with 418 survivors in the control arm of the study and 381 survivors in the intervention arm. The average age range was 47-66 years, with the overall average for the combined studies being 54.7 years. Due to 6/8 studies dealing with predominantly female cancer types (breast and cervical), the majority of the patients (64%) were female. The average PEDro score across studies was 7.0±1.0.

Five of eight articles did not show a statistically significant improvement in the QOL assessment scores for survivors in the intervention compared to the control groups from baseline to end of the intervention. David et al. (2011) found no significant differences in change of mean QOL between those who participated in the free psycho-social counseling email group and those who were on the waitlist control.[171] Freeman et al. (2015) did not find significant differences for the breast cancer survivors in the intervention arm compared to those in the waitlist or live delivery arm.[21] However, there were significant increases in quality of life (≥3 points) for both those in the videoconferencing telehealth and live delivery intervention groups compared to the

control group. The telehealth delivered program showed the greatest improvement in QOL of 5.12 points, compared to the same program given in-person, which showed an increase of 3.55 points from baseline, and the waitlist had a slight increase of 2.4 points from baseline to the 3-month post-intervention assessment.[21] Freeman et al. (2015) noted in their study limitations the differences between sample sizes in each group may have led to the variability in the increase in QOL scores, as the telemedicine delivery group was just under half the size as the in-person delivery and control groups.[21]

Similarly, Malmstöm et al. (2016) did not find a significant difference ($p=0.698$) in QOL between the change in the means of the intervention and control oesophageal cancer survivor groups.[172] This study utilized a nurse-led telephone supportive care program with the final assessment at 6 months after starting the intervention. The intervention did have significant effects on the survivors' experience in the intervention group compared to the control group, including information about 'things to do to help yourself' ($p=0.001$), written information ($p<0.001$), and the global information score ($p< 0.001$).[172] In a study using the Breast Cancer E-Health (BREATH) trial, a web-based self-management intervention, van den Berg et al. (2015) determined there was no significant difference ($p=0.290$) in the effect of the intervention on the mean QOL scores when comparing those who received the intervention compared to those receiving UC.[173]

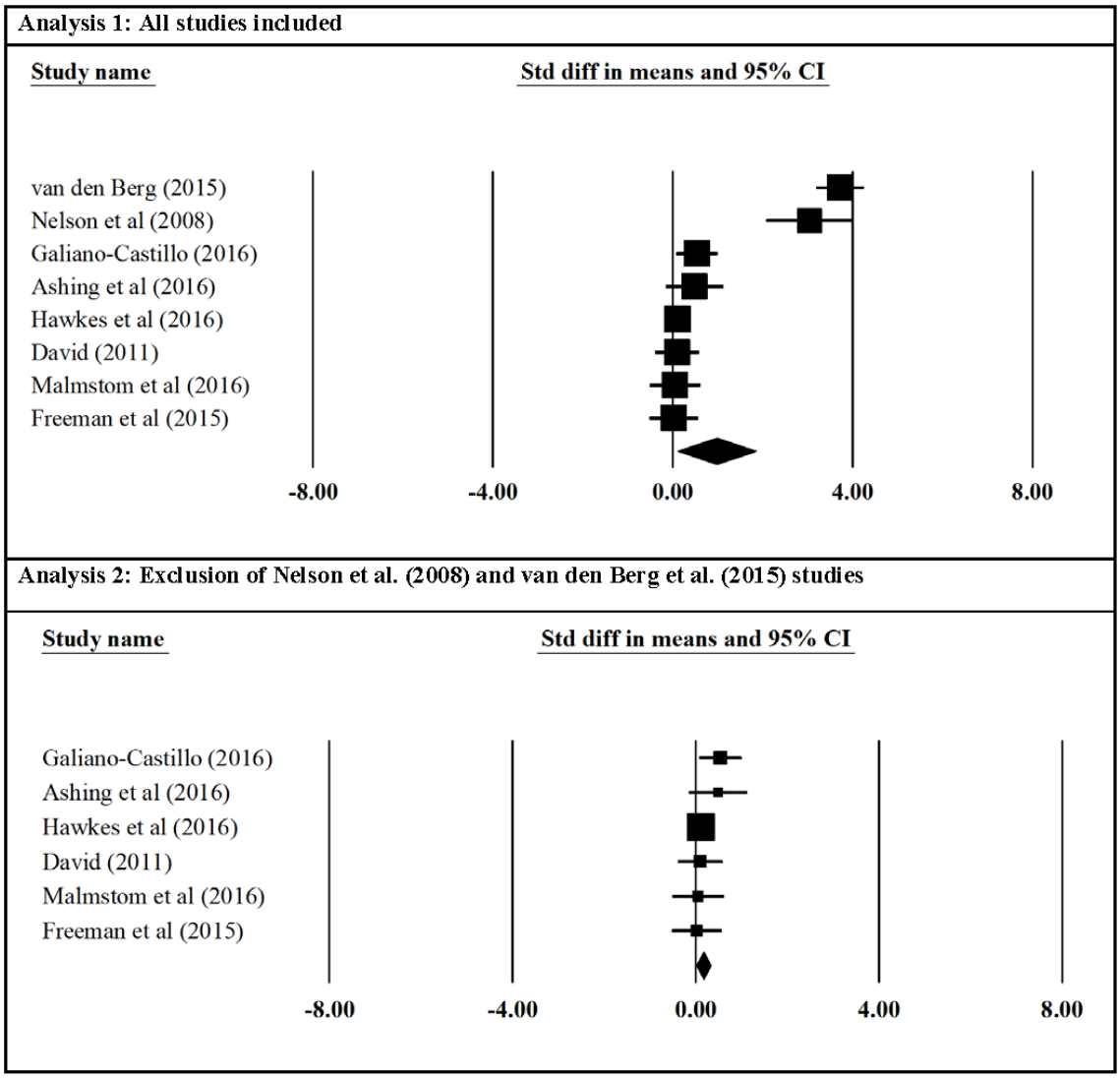
Hawkes et al. (2014) also found no significant change in QOL for colorectal survivors when comparing those in usual care to those in a telephone health coaching program.[161] Although both groups showed improvement in QOL over time; there was no difference between the two groups at 6 months or 12 months. However, there were

significant increases in the differences of the mean of the treatment group compared to the mean of the control group in the physical well-being category of the QOL assessment ($p<0.05$) at both assessment time points from baseline.[161]

Three of the eight studies found significant changes in the mean score of the QOL of those within a telehealth intervention compared to those in usual care. Nelson et al. (2008) utilized telephone counseling as the intervention for uterine cervix cancer survivors and compared that to UC, measuring mean QOL at baseline and 2 weeks after the last counseling session.[174] The intervention group of cancer survivors saw an average increase in their overall QOL score of 6.7 points, while the control group had no improvement. The difference in the baseline mean QOL to the mean QOL post-intervention was significant ($p=0.011$) comparing those in the intervention group to those in the control group.[174] Ashing and Miller (2016) found a significant difference in overall QOL from baseline to end of intervention timeframe (4-6 months) for breast cancer survivors in their telephone intervention compared to those in UC ($p=0.049$).[175] Galiano-Castillo et al. (2016) utilized an internet-based tele-rehabilitation program called e-CUIDATE and assessed patients QOL at baseline and follow-up at 6 months after intervention. The change in overall health QOL was statistically significant when comparing the UC control with those in the program ($p<0.001$).[176]

In total, 8 individual effect sizes were calculated for the mean differences in QOL from baseline to post-intervention comparing telehealth intervention group to UC control. The distribution for all unweighted effect sizes calculated are displayed on the upper forest plot in Figure 5.5.

Figure 5.5: Forrest Plot of The Standard Difference in Means and the 95% Confidence Interval (CI) by Name of Study.



The summary statistics for the mean effect sizes for telehealth and UC with their 95% confidence intervals, heterogeneity statistics and fail-safe N calculations are reported in Table 5.4 as Analysis 1. There was a statistically significant large mean effect compared to baseline across the included studies (Δ=0.980, p=0.028). However, when assessing publication bias, there were several outliers in the homogeneity of studies

(Figure 5.6). The two articles leading to increased heterogeneity of the mean effect were Nelson et al. (2008) and van den Berg (2015).

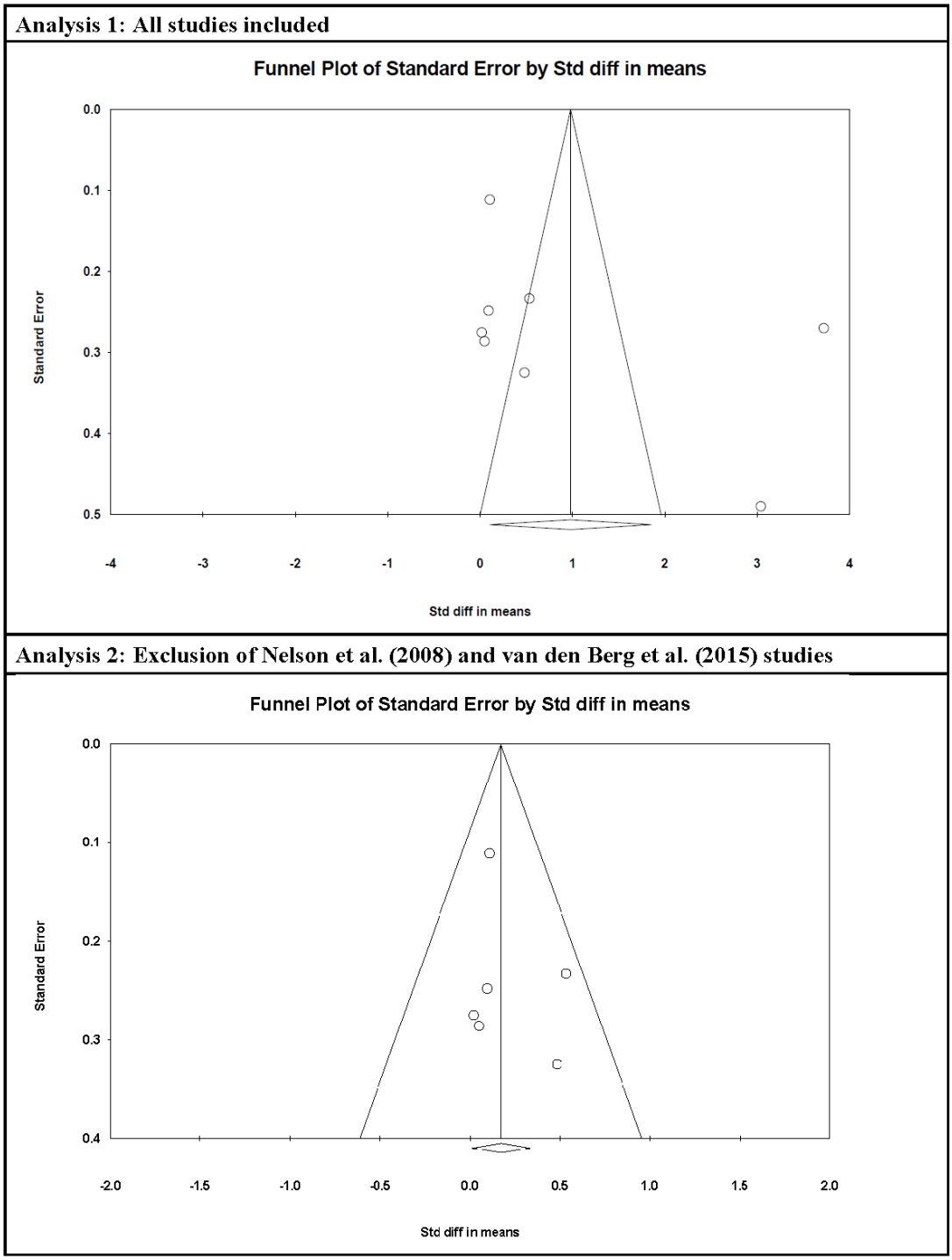
Table 5.4. Summary Statistics for Telehealth Intervention and Usual Care Across All Included Studies

Intervention	n	Mean Δ (95% Confidence Interval	*p*	*Q*	I^2	*Fail Safe n*
Analysis 1[a]	8	0.980 (0.108, 1.852)	0.028	189.5	96.3	161
Analysis 2[b]	6	0.172 (0.012, 0.332)	0.036	4.3	0.0	2
Analysis 3[c]	7	1.113 (0.106, 2.120)	0.030	186.1	96.8	157
Analysis 4[d]	5	0.181 (0.011, 0.351)	0.036	4.2	3.6	2

[a] Includes all 8 studies
[b] Excludes Nelson et al. (2008) and van den Berg (2015)
[c] Excludes David et al. (2011)
[d] Excludes David et al. (2011), Nelson et al. (2008) and van den Berg (2015)

In the lower half of Figure 5.5, the distribution for all unweighted effect sizes calculated are displayed in a forest plot, excluding the Nelson et al. (2008) and van den Berg et al. (2015) articles.[173,177] The mean effect was still significant (p=0.036), but the effect size was much smaller than in the first model (**Δ**=0.172). The summary statistics are reported in Table 5.4 as Analysis 2. Figure 5.6 shows the reassessment of publication bias and the overall homogeneity of the studies after exclusion of the outlier.

Figure 5.6: Funnel Plots of the individual study effect sizes plotted against the standard error



Both analysis models described above were run without the David et al. (2011) articles, due to a vague description of the population included in this study. This additional analysis was to determine if this study had a major effect on the intervention compared to UC. With all 7 articles in the analysis, excluding David et al. (2011), there was a statistically significant large, mean effect (**Δ**=1.113, *p*=0.03). After excluding David et al., Nelson et al., and van den Berg et al., the result was similar to the second analysis. There was still a statistically significant mean effect but it was considered small (**Δ**=0.181, *p*=0.036). The summary statistics for the mean effect sizes for telehealth and UC with their 95% confidence intervals, heterogeneity statistics and fail-safe N calculations are reported in Table 5.4 as Analysis 3 and 4, respectively. This analysis is similar to our original analysis, which indicates that even without the article by David et al., the telehealth intervention had a significant mean effect.

Five of the articles focused on breast cancer and three on other forms of cancer. A sub-analysis demonstrated negligible differences between the two groups mean effect and, while each effect was considered large, due to the low study sample, neither sub-analysis group had a statistically significant mean effect (breast cancer **Δ**=0.973, *p*=0.159; other cancer **Δ**=0.972, *p*=0.133). In the case of this analysis, cancer type does not appear to be a factor affecting the mean effect outcome.

Another sub-analysis by technology type was conducted where we compared the 4 telephone-based studies to the 4 studies using web-based technology. The web-based programs had a slightly higher mean effect (mean Δ=1.093, *p*=0.197) than those in the telephone group (mean Δ=0.819, *p*=0.075), but neither mean effect was significant in the

change of QOL in telehealth intervention compared to UC. Technology type in the case of survivor programs does not appear to be a significant factor in influencing outcomes.

Three of the articles used Functional Assessment of Cancer Therapy (FACT) assessments of QOL and 4 articles used the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 items (EORTC-Q30) survey. Sub-analysis of these groups yielded similar results to the previous sub-analyses. Neither the FACT assessment group nor the EORTC-QLQ-C30 assessment group had statistically significant mean effects. The FACT assessment group had a mean effect size of 1.135 (p=0.104), and the EORTC-QLQ-C30 group had a mean effect size of 1.101 (p=0.195). This leads to the conclusion that the type of QOL assessment used does not affect the outcome of this analysis. All statistics of the three sub-analyses are provided in Table 5.5, including mean effect, 95% confidence intervals, and p-values.

Table 5.5. Summary Statistics for Sub-Analysis of Telehealth Intervention vs Usual Care Across All Included Studies

Sub-Analysis Group	n	Mean Δ (95% Confidence Interval)	*p*
Telephone Intervention	4	0.819 (-0.084, 1.722)	0.075
Web-based Intervention	4	1.093 (-0.567, 2.754)	0.197
Breast Cancer Group	5	0.973 (-0.382, 2.327)	0.159
Other Cancer Type Group	3	0.972 (-0.296, 2.240)	0.133
FACT Assessment	3	1.135 (-0.232, 2.503)	0.104
EORTC-QLQ-C30	4	1.101 (-.0563, 2.766)	0.195

FACT-Functional Assessment of Cancer Therapy; EORTC-QLQ-C30- European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 items

IV. Discussion

Our study performed a systematic review and meta-analysis of peer-reviewed studies that utilized telehealth interventions to improve the emotional support or self-

management of symptoms of cancer survivors. Our analyses of included articles demonstrated a statistically significant, large effect of telehealth interventions on increasing survivors' quality of life compared to UC. Telehealth interventions that utilize additional support for cancer survivors appear to improve their QOL compared to the standard UC.

The studies in our meta-analysis and systematic review were relatively homogenous as demonstrated by the funnel plots (Figure 5.6). Nelson et al. (2008) was one of the outliers showing significantly improved effectiveness of telehealth versus UC, with survivors in the control group showing a decrease in QOL, the only study to show this effect. This was the only study analyzing patients with cervical cancer and had the youngest average age.[174] van den Berg et al. (2015) was the second outlier, also showing a significant increase of telehealth intervention survivors' QOL compared to less than a tenth of a point increase in QOL of UC survivors. However, the van den Berg et al. (2015) article was one of several breast cancer studies.[173] These two studies use different telehealth technology (telephone and web-based), are differing cancer types and are similar in age or gender to the majority of the other studies. It is possible that telehealth-based psychosocial treatments would vary in effectiveness across cancer diagnoses, age groups, and modality of delivery. Unfortunately, there has been insufficient research to demonstrate this.

These findings are somewhat in contrast to a systematic review and meta-analysis of cancer patients undergoing treatment that did not show significant effect of telehealth support interventions on patients' QOL compared to UC.[75] This may be due to the

differences in survivors compared to their counterparts still receiving cancer therapies, which affect each patient differently and can cause multiple issues, including physical, functional, and psychosocial symptoms and complications.[19,22,118–121] Patients may have different physical and psychological symptoms while in treatment compared to after completing active treatment. We also chose to focus on overall QOL compared to more specific elements of QOL, because, as our healthcare system transforms from an enterprise of "sick care" to one that emphasizes overall health and prevention, we sought to take a holistic approach.[178]

As opposed to overall assessments of QOL, some studies have chosen to look at specific aspects of QOL and have shown differing effects in telehealth interventions. In a meta-analysis of the effect of telehealth interventions on aspects of QOL in breast cancer survivors, the study demonstrated that telehealth interventions reduced survivors' depression and distress levels, improved self-efficacy, but had no significant effect on anxiety scores.[163] Hawkes et al.(2014) found a statistically significant difference in the mean of the intervention group compared to control for the QOL subset physical well-being, but not overall QOL.[161] Thus, there may be areas of QOL that are more improved than others in the use of telehealth interventions for cancer survivors. Alternatively, David et al. (2011) determined that, although there was no statistical difference in control and intervention groups, the survivors in the intervention found the counseling service helpful and regarded it as a positive in their lives.[171] Similarly, Malmstöm et al. (2016) found a statistically significant effect of supportive telephone care on patient experience, including satisfaction and access to information.[172] Therefore, although some studies may

not show a statistically significant effect in overall QOL, there are areas of a survivors' life that are improved through the use of telehealth support programs.

Our inclusion criteria stated that all articles must have an overall quality of life measurement. Of the eight studies in our systematic review, half used the EORTC-QLQ-C30 survey. The European Organization for Research and Treatment of Cancer quality of life questionnaire (EORTC QLQ-C30) is an integrated system for assessing the QOL of cancer patients participating in clinical trials and other types of research in which patient-reported outcomes are collected.[179] The EORTC QLQ-C30 includes 9 multi-item scales, including functional, symptom, and global health scales. There are 5 functional scales and six single symptom measures.[179] All of the scales and single-item measures range in score from 0 to 100. A high scale score represents a higher global health status score equating to a higher QOL.[179]

Three articles utilized the FACT instrument, either the general or cancer-specific FACT instrument, as shown in Table 1. FACT-G is a 27-item instrument that has subscale scores for physical, functional, social, emotional well-being and satisfaction with treatment.[143] Cancer-specific FACT scales include those questions that are in the FACT-G but have additional questions that are cancer specific, such as for colorectal cancer (FACT-C), and cervical cancer (FACT-Cx). Freeman et al. (2015) used the Medical Outcomes Study 36 item short form survey (SF-36).[21] The SF-36 includes one multi-item scale that assesses eight health concepts: limitations in physical and social activities due to physical or emotional problems, limitations in usual role activities due to physical or emotional problems, bodily pain, general mental health (psychological

distress and well-being), vitality (energy and fatigue), and general health perceptions.[180] Like the other QOL assessments in this meta-analysis, the SF-36 correlates higher scores with higher QOL.

Our sub-analysis of grouping studies based on differing characteristics yielded no statistically significant results of mean effect on the change in QOL of those in the intervention groups compared to those in the UC groups. When we separated the studies by technology type, telephone and web-based, neither had statistically significant mean effect sizes. The mean effect was larger in the web-based intervention, but both were similar to the first analysis in the study and had wide confidence intervals. The sub-analysis of cancer types yielded similar results. Breast cancer and other cancer types had very similar mean effect sizes, and neither was statistically significant. The breakdown of cancer evaluation also yielded mean effect sizes that were not statistically significant. This differs from a recent meta-analysis of cancer patients in treatment where the QOL assessment used made a significant difference in the mean effect of those in the telehealth intervention compared to those in UC.[75] However, like the cancer patient in treatment meta-analysis, the mean effect for the FACT assessment study group had a larger mean effect than those using EORTC-QLQ-C30, although not statistically significant.[75]

We utilized the PEDro scale to determine the quality of the RCT studies, as noted in Table 1. All the studies fell in the range of 6 to 8 out of a total of 11 points. The majority were 7 points, with all studies unable or not providing information on blinding subjects, therapists, or assessors. Galiano-Castillo (2016) and van den Berg (2015) were assessed slightly higher at 8 points, as both studies had concealed allocation, whereas the

other 6 articles did not report this factor.[173,176] David et al. (2011) had the lowest quality score of 6, as the authors did not state thoroughly who was being included and excluded and for what reasons, contributing to the study's relatively low PEDro Score.[181]

V. Conclusion

Study Limitations

Our study should be interpreted in the context of certain limitations. Our meta-analysis had a small sample size of manuscripts and patient pools, and therefore we were unable to perform a complete moderator analysis to determine if alternative factors influenced the effectiveness of treatment delivery. Similarly, different cancers, stage of cancer and treatment protocols may have varying impacts on QOL, which we were unable to fully explore due to the limited number of studies. Although we attempted to correct the heterogeneity of articles by excluding outliers, it did significantly affect the mean effect size. However, there was still significant effect in every analysis and some differences related to factors in the sub-analysis of differing groups.

Clinical Implications

Our systematic-review with meta-analysis demonstrated that supplementary interventions through telehealth have a statistically significant positive impact on the quality of life scores relative to in-person usual care. Some of the studies in this meta-analysis did see improvements in other areas such as depression, anxiety, and emotional, social, and physical well-being, even when the overall quality of life was not statistically significantly improved. The additional benefits of telehealth are increased access for rural

patients and those who may struggle to get to in-person resources, as well as improving patient satisfaction.[140,142,171,172] Our findings suggest more studies need to be conducted on the impact of telehealth interventions across different cancer diagnoses and delivery modalities, to gain better insight into the effectiveness these interventions may have on quality of life for cancer survivors in all phases of survivorship.

C. Comparison of Cancer Patients in Treatment and Cancer Survivors: Meta-Analysis

I. Introduction

The previous meta-analyses that examined the effect of emotional support and symptom management telehealth programs on the QOL of cancer patients in treatment and cancer survivors resulted in different outcomes in the significance of the effect. The two meta-analyses were done slightly differently due to the inclusion criteria for peer-reviewed articles. In the cancer patient meta-analysis, we chose to include studies that were not RCTs for the purpose of increasing the number of articles in our analysis and increasing the power of the study. To better understand the differences in the effect size on patients in different stages of cancer treatment, a meta-analysis of the RCT articles from each of the previous studies will be conducted. This comparison assesses if the non-significant effect of telehealth interventions for cancer patients in treatment is significantly different from the effect of telehealth that was observed to be statistically significant in the survivor meta-analysis. The purpose of this analysis is to inform when the timing of these telehealth interventions will be more effective for improving patients' (both in and out of active treatment) QOL.

II. Methods

The data that was pulled from the RCT articles in the cancer patient meta-analysis was combined with the RCT data extracted for the cancer survivor meta-analysis, which included sample sizes, QOL measures means and standard deviations from baseline and post-intervention, as well as effect sizes for each study whenever data were available.

A random effects model was utilized again to mitigate the heterogeneity of the studies. The first model run included the total 16 RCT studies for cancer survivors and cancer patients. An overall effect size was determined without separating subgroups. Sub-group analysis was run to compare the effect sizes for each sub-group and determine the significance of the difference between groups. Heterogeneity was assessed via I^2 and Q-statistics. Comprehensive Meta-Analysis software package[129] was used to calculate the overall and sub-group effect-sizes and heterogeneity statistics. Effect size data were interpreted as 0.1-0.3=small, 0.3-0.5=moderate and >0.5=large effects.[130]

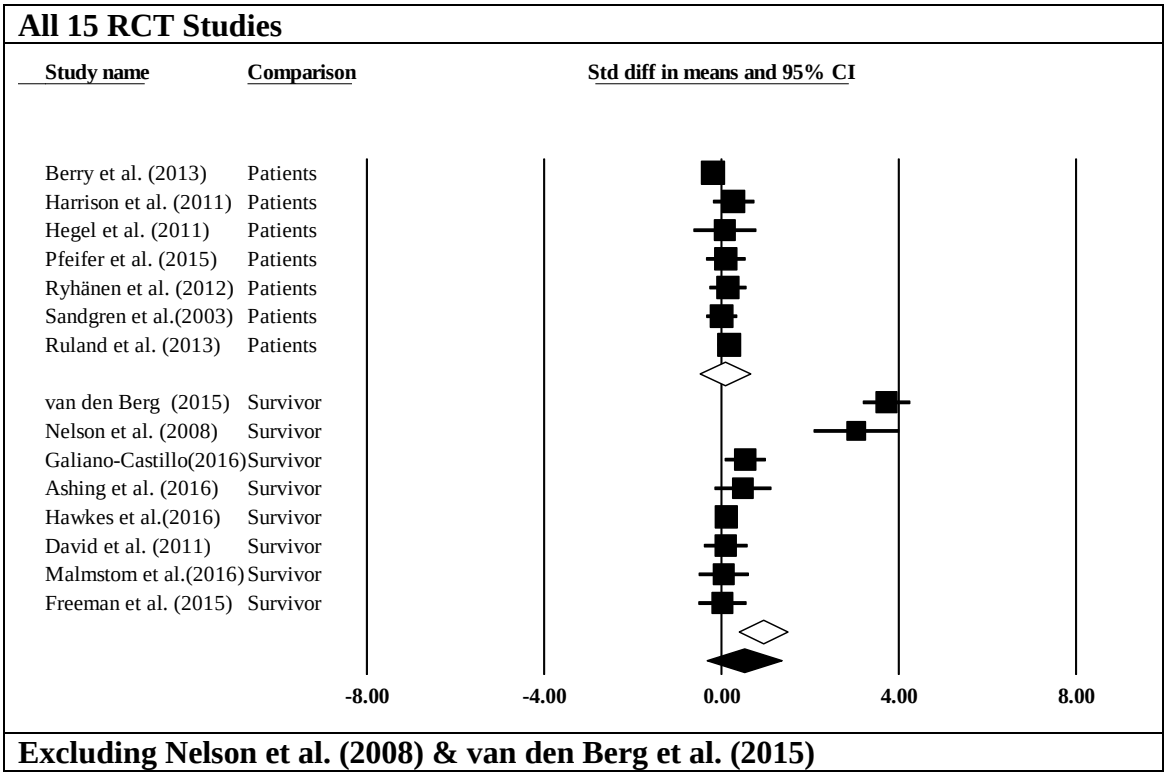
Due to the same heterogeneity that was seen in the original meta-analyses of cancer patients and cancer survivors, the analysis was done without outlier studies. The second analysis was completed without the two cancer survivor outliers, Nelson et al. (2008) and van den Berg et al. (2015) articles.[173,174] After recalculating heterogeneity and observing the coinciding funnel plot, the Berry et al. (2014) study[137] was also removed from the third analysis. This created a homogenous study group for each sub-group.

Table 5.6: Included RCT Studies from Cancer Patient and Survivor Meta-Analyses

Cancer Patients In Treatment Study Articles	Cancer Survivor Study Articles
Berry et al. (2014)	van den Berg (2015)
Harrison et al. (2011)	Nelson et al (2008)
Hegel et al. (2011)	Galiano-Castillo (2016)
Pfeifer et al. (2015)	Ashing et al. (2016)
Ryhänen et al. (2012)	Hawkes et al. (2016)
Sandgren et al. (2003)	David et al. (2011)
Ruland et al. (2013)	Malmstöm et al. (2016)
	Freeman et al. (2015)

III. Results

Figure 5.7: Forrest Plot of the Standard Difference in Means and the 95% Confidence Interval (CI) by Name of Study



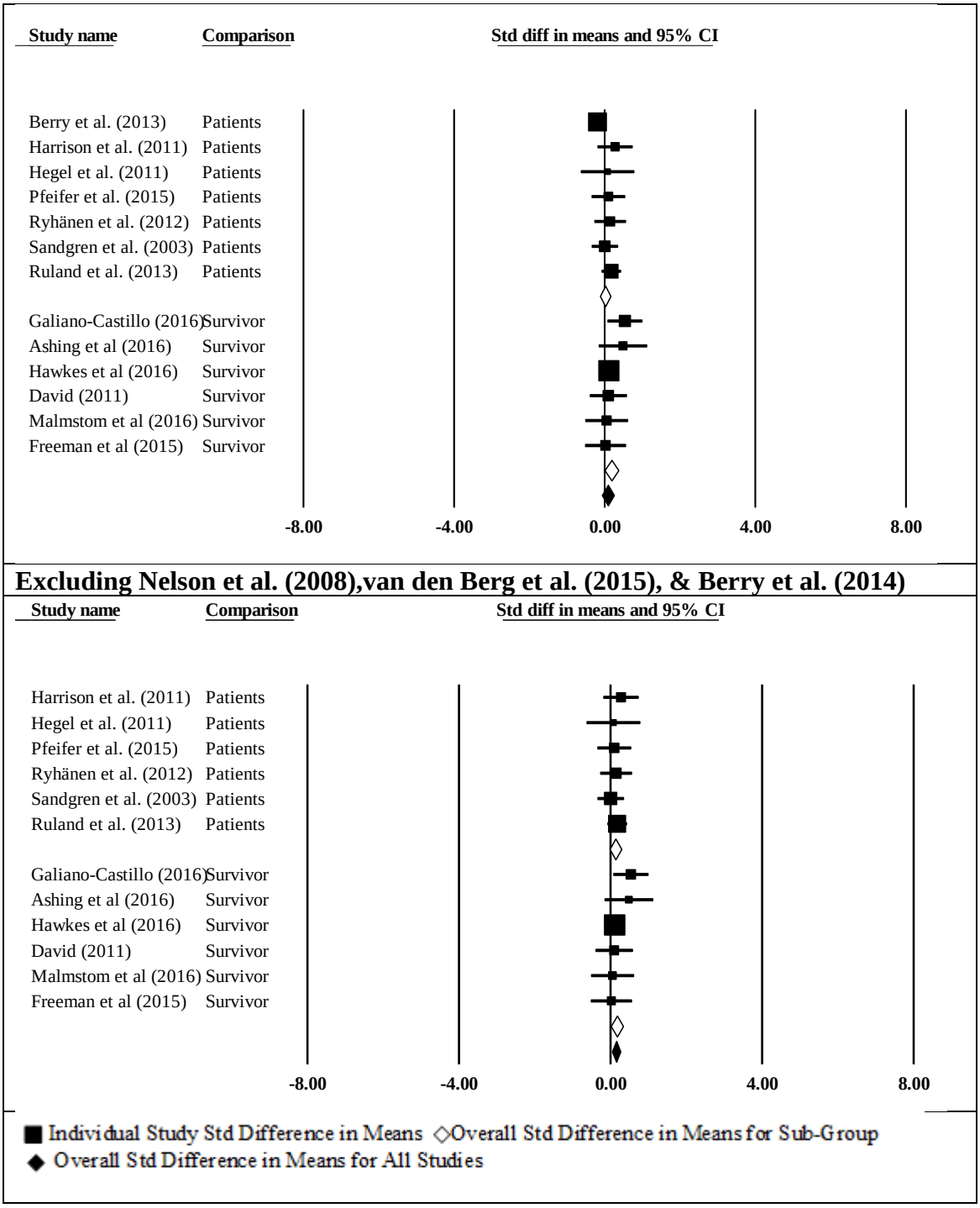
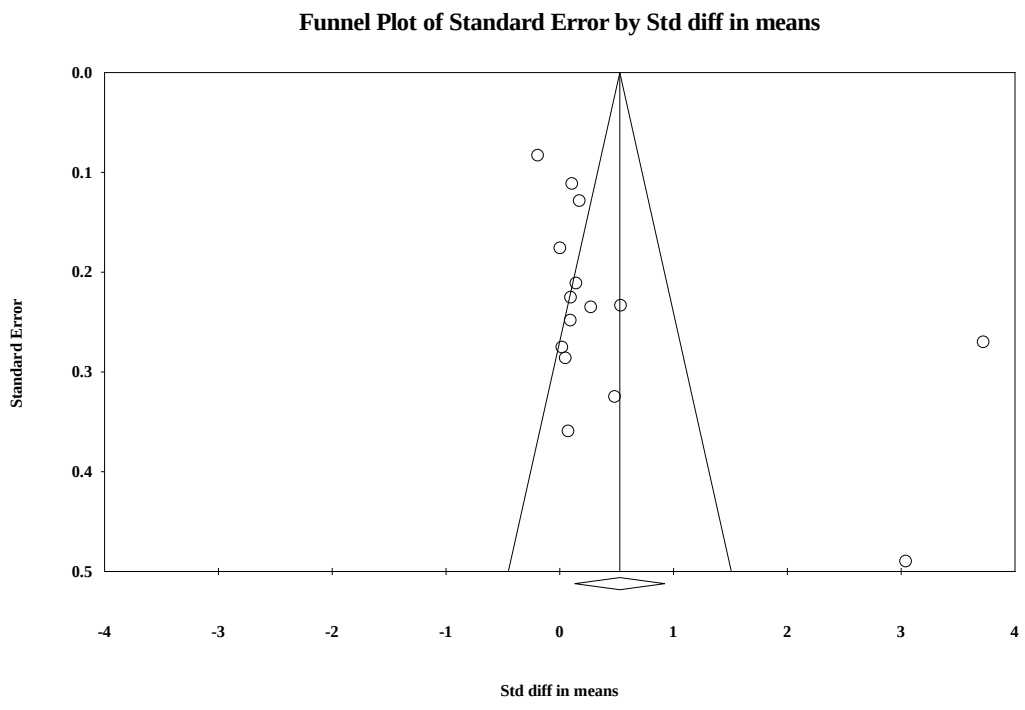


Figure 5.7 shows the progression of Forrest plot mean effects as studies are extracted. In the first diagram, the survivor mean effect is higher and more dramatic due to the pull from the two outliers. As studies are excluded, the group of studies became

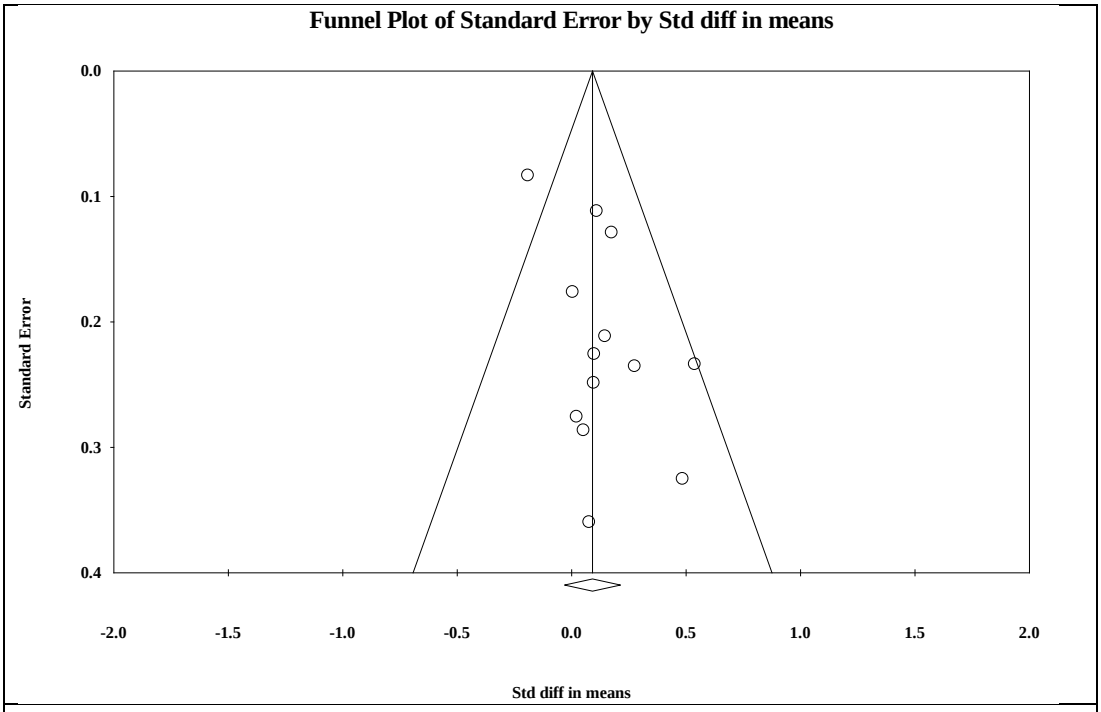
more homogenous and centered on the overall effect mean. The lack of outliers in either group makes the sub-group comparison more accurate as the mean effect for each sub-group is more realistic to what the true mean effect is for that sample population. Figure 5.8 contains the corresponding funnel plots for each analysis. As the studies are removed, the homogeneity of the articles increases.

Figure 5.8: Funnel Plots of the Individual Study Effect Sizes Plotted Against the Standard Error

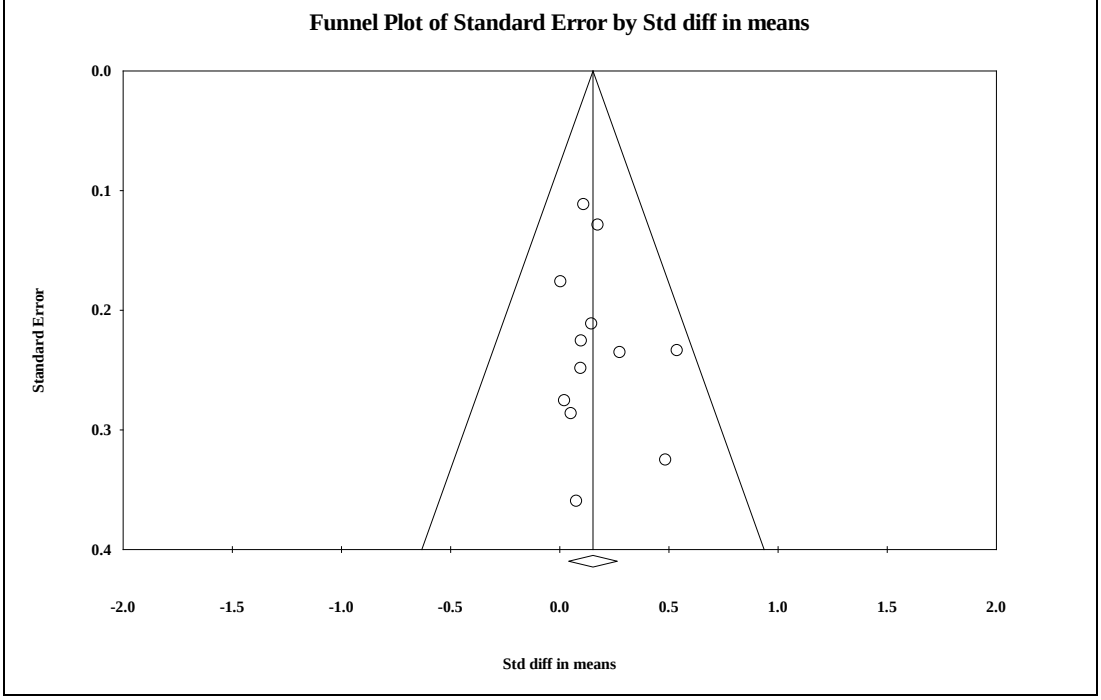
All 15 RCT Studies



Excluding Nelson et al. (2008) & van den Berg et al. (2015)



Excluding Nelson et al. (2008),van den Berg et al. (2015), & Berry et al. (2014)



The comparison statistics are denoted in Table 5.7 and include the within and between variance of the studies. The combined overall outcome is the difference in means calculated for all studies as one group. For the 15 RCT studies combined this yielded a mean effect of 0.515, but it was statistically insignificant. The Q value for the total outcome was statistically significant, denoting that despite sub-groups the effect size varies between all studies. The patient and survivor sub-groups are then run separately to determine the effect size of each. In this analysis, the survivors sub-group has a large effect size that is statistically significant. However, this is mitigated by the total within variance.

The Q is statistically significant for the total within sub-groups, which denotes the true effect size varies within sub-groups. The total between Q value is used to determine if the effect size statistically differs between the two sub-groups. In this analysis, it is statistically significant. So there is a statistically significant difference between the effect size of telehealth interventions on the QOL of cancer survivors when compared to the effect of similar intervention on the QOL of cancer patients in treatment.

The following analyses are set up in the same way with the combined overall effect being calculated, along with sub-group effects and variance being calculated. However, as the homogeneity of the articles grows the variance within the sub-groups and between the sub-groups decreases in the Q value and becomes insignificant. To note in the second analysis with 13 RCT values the fail-safe *n* is 0 because the *p*-value for the combined effect is already greater than alpha equal to 0.05. The fail-safe n is the number of articles that are “missing” from the analysis that would bring the *p*-value above the

designated alpha. In the final analysis, which has the greatest homogeneity, the overall and sub-group effect sizes are much lower. However, the overall effect and the survivor effect size are both significant. This lends to the assertion that for certain populations, especially cancer survivors who are no longer in active treatment, telehealth emotional support and symptom management programs do produce a significant effect on the person's QOL.

Table 5.7 Summary Statistics for Sub-Group Comparison Analysis of Cancer Patient versus Cancer Survivors

	n	**Mean Δ (95% Confidence Interval**	***p***	***Q***	***I^2***	***Fail Safe n***
Comparison of 15 Articles						
Combined Overall Outcome	15	0.515 (0.330, 1.360)	0.232	231.74**	93.96	175.0
Patients	7	0.081 (-0.490, 0.651)	0.781	9.08**	33.92	NA
Survivors	8	0.943 (0.393, 1.493)	0.001	189.50	96.31	NA
Total Within	NA	NA	NA	198.58**	NA	NA
Total Between	NA	NA	NA	4.55*	NA	NA
Comparison of 13 Articles, Excludes Nelson et al. (2008) & van den Berg (2015)						
Combined Overall Outcome	13	0.089 (-0.072, 0.250)	0.278	17.04	29.56	0.00
Patients	7	0.018 (-0.122, 0.157)	0.804	9.08	33.92	
Survivors	6	0.183 (-0.001, 0.367)	0.051	4.25	0.00	
Total Within	NA	NA	NA	13.33	NA	NA
Total Between	NA	NA	NA	1.973	NA	NA
Comparison of 12 Articles, Excludes Nelson et al. (2008), van den Berg (2015), & Berry et al. (2014)						
Combined Overall Outcome	12	0.152 (-0.021, 0.288)	0.007	5.42	0.00	11
Patients	6	0.134 (-0.021, 0.288)	0.090	1.06	0.00	NA
Survivors	6	0.172 (0.012,0.332)	0.036	4.25	0.00	NA
Total Within	NA	NA	NA	5.31	NA	NA
Total Between	NA	NA	NA	0.11	NA	NA

*$p < 0.05$
**$p < 0.001$

IV. Discussion

The comparison of the RCT articles from the previous meta-analyses of telehealth emotional support and symptom management programs on the QOL of cancer patients in treatment and cancer survivors was to increase the knowledge of when are these services most effective. The independent analyses that were done had yielded different results in significant effect. This led to a hypothesis that survivors may be a better target for telehealth interventions directed at improving their quality of life. The results of the first analysis containing all the RCT studies did show a significant difference in the effect of the interventions when compared between the two sub-groups. However, as the homogeneity of the two groups became more similar, the effect size variance between groups was not significant. This homogeneous group, however, did have a small but statistically significant overall effect size for improving the QOL of cancer patients and survivors.

Of the 15 original articles, 8 studies were of breast cancer, one contained both breast cancer and prostate cancer patients with 60% of participants being female,[134] and one article was open to all cancer patients with the majority being breast cancer patients.[137] When the outlier articles were removed there were 7 breast cancer only studies and the breast cancer and prostate article. [134] The predominance of female breast cancer patients in the final homogenous analysis brings up the topic of the type of cancer patients that will see the greatest effect from this form of emotional support and symptom management.

V. Conclusion

Although the meta-analysis study comparison of cancer patients in treatment and cancer survivors is limited in the number of study articles, the results bring up very important questions, especially for healthcare providers. When telehealth services thrive or wither, part of this is due to the demand for these services and the outcome of the programs. Timing of services is essential to them being effective for patient outcomes. This comparison analysis lends to the idea that emotional support and symptom management telehealth services should be directed at patients in later stages of treatment or those no longer in active treatment, especially targeting breast cancer patients in order to have the largest effect on patients' quality of life.

Chapter 6: Discussion

These three studies were framed within a hybrid model created by interconnecting the concept of Complex Socio-Technical Systems with the theory of Ready, Willing, and Able. The aim of these studies was to assess aspects of telehealth technology at multiple hierarchical levels of the CSTS that would facilitate or hinder all three preconditions of RWA from being met. This discussion will be framed within the RWA preconditions to lend to a better understanding of each concept and the interconnected findings of these three studies.

I. Ready

Readiness is the perception that an innovation is beneficial and advantageous for the person, population, or organization. Study 1 analyzed several variables within three CSTS levels (ecosystem, organization, and process) to determine the association to a hospital wanting to implement telehealth or RPM, but not having the resources. In effect, it was comparing hospitals at different stages of implementation which also had met differing conditions of RWA. Hospitals that had less technological infrastructure, so neither provider portals or secure messaging, were less likely than hospitals with these technologies to have met all RWA preconditions. Study 2 analyzed aspects of Nebraska clinics in relation to telehealth use in three forms (live video, store and forward, and RPM). Although study 2 focused on barriers to implementation and maintaining sustainability, there was an association with having between provider technology and use of between patient and provider telehealth services. Having a sound technology infrastructure can facilitate the organization's readiness to adopt telehealth technologies.

On the other hand, not having a solid technology infrastructure can hinder readiness, as the cost of implementation, both buying equipment and employee time, may outweigh the projected benefits. Once in use, lack of infrastructure can become a barrier to maximizing the telehealth technologies potential benefit. Many clinic staff interviewed in study 2 discussed technology connection issues and staff personnel not know how to deal with unforeseen events. These negative events will hinder an organizations readiness in the future, as there will be a bias created by the technology currently in place and the benefits may be downplayed and the cost of investing overinflated.

Demand for services that are not readily available within the community can be a facilitator to readiness for innovation. Study 2 yielded results associated with community demand within the qualitative analysis. Several clinics stated that demand for services in the community led them to find solutions to provide the needed services. The most cost-effective way to do that was through telehealth services; it negated the need for providers to travel to distant clinics or for patients to travel to distant providers. What could be a 3-hour trip to see a specialist could be a 30-minute appointment in their local clinic with the use of telehealth technology. This was beneficial for the patients and also the clinic as patients were more satisfied but it also allowed them to keep some charges within the revenue pool of the clinic.

Study 3 was a combination of meta-analyses to determine the effect of telehealth programs on the quality of life of cancer patients and cancer survivors. The goal of the telehealth programs within the articles chosen for the study was to fill a gap in cancer patient/survivor care. Several articles noted improvements in patient quality of life. The meta-analysis on cancer survivors yielded a significant effect on the QOL of patients in the telehealth programs compared to those receiving usual care. Positive patient outcomes are a facilitator for organizations to meet the precondition of readiness to adopt an innovation. This builds up the benefit of the technology to the extent that it can outweigh the costs. This was also discussed by a home healthcare clinic administrator when discussing the benefits of RPM technology. As policy changes become more centered on quality of care indicators, there is a need to decrease events such as rehospitalization and falls. RPM allows the clinic to care for patients more continuously and decrease these

adverse events, leading to better reimbursement. In the case of this facility, they are not only trying to improve quality for reimbursement purposes but also to gain a competitive edge in the market. Therefore, despite some limitations in reimbursement policies for RPM, the organization saw greater combined benefits than costs in relation to the use of telehealth technology.

II. Willing

The same positive patient outcomes noted in the meta-analyses related to the use of telehealth programs to support cancer patient and survivors also improve organizations willingness to adopt telehealth technologies. Willingness is the legitimization and the acceptance of new technology as normative. Within the mixed methods study, many clinic staff conferred that continued use of telehealth technologies made the technology part of the normal clinical services. Patients' acceptance was never seen as an issue, with few patients ever refusing to use telehealth to gain access to healthcare providers. One clinic manager was of the opinion that as the population becomes more engrossed with technology in general, such as using cell phones and tablets in our personal lives, that there would be a rise in telehealth technologies. This is a key point for gaining that acceptance of normalization.

Positive patient outcomes don't only impact readiness but also the willingness of organizations to adopt a new innovation. Many of the factors within the RWA framework overlap, as this is a complex system, where each component is associated with another one or multiple components. The meta-analyses yielded improvements in quality of life, particularly for cancer survivors receiving telehealth interventions. Study 2 also provided

insights into patient satisfaction with telehealth and the benefits to the patient, such as not needing to travel long distances to receive care. The more measurable positive outcomes, such as these that legitimize the use of telehealth technologies, the more organizations will be willing to accept the innovation.

The meta-analyses also form another rung in the ladder toward legitimization and acceptance within the field of oncology and psychiatry. There is a demand that is found by the study investigators for continued emotional and symptom management support, and they utilize different methods to provide services to their cancer patients. The greater amount of studies that show positive outcomes with a standardized evaluation process the larger the increase in the legitimization of this method for providing healthcare. One article, about one clinic, with one patient population, can only say so much about the benefit or lack of benefit related to utilizing telehealth technology. The point of a meta-analysis is to combine these together in a way that will gain power and legitimize the positive or negative effect of the individual studies. [182]

Legitimization of an innovation can also come from government policies and organizational backing. In study 2, telehealth service providers who provided services across state lines discussed interstate licensure compacts. Facilitating easy processing of licensing for telehealth providers can improve organizations willingness to adopt telehealth technology. Government policy changes for reimbursement of telehealth services can legitimize the use and benefits of telehealth technology. These activities infer a backing of higher authorities to the legitimization and acceptance of the technology. However, as discussed in study 2 there can still be pushback within a

professional community, such as physicians seeing telehealth as an affront to the traditional medical practice. This could relate to the significant findings of the association of increased average age of clinic providers and decreased odds of using live telehealth technology among Nebraska clinics. One clinic manager noted that "*new providers, when they come in, don't seem to have a problem with it.*" Although not conclusive, it leads to the question, is it already more of an accepted norm for younger providers than those who are older? Older providers potentially being taught a more traditional medical practice curriculum than current medical schools provide.

III. Able

An innovation can only be adopted if the organization has the ability to access the innovation. Clinical service providers must have the needed infrastructure, personnel, time, networking partner, and financial resources to implement and sustain telehealth services. All three studies touch, to some extent, on the ability of healthcare providers to provide telehealth services in a manner that is optimal for the organization and the patient population. Study 1 is evaluating multi-level factors to see which perpetuate and which lessen the likelihood of being an organization that is ready and willing but lacking the ability to implement telehealth technology. Organizations that provided specialty care services were more likely to lack the ability to adopt telehealth compared to general care providers when the dependent variable was hospitals that have met all three preconditions compared to those that lack ability. However, when compared to those that hospitals that had not implemented and did not plan to, specialty providers were less likely to be lacking the resources than general care providers. Many specialty hospitals and clinics

are going to be smaller and provide specific services. Their patients would not demand of them to offer any other services that would be out of their specialized field as patients are most likely referred there for one intended purpose. In contrast, general care providers or primary care providers can be the only access to healthcare patients in a community may have. This puts more demand on primary care facilities to be all-encompassing for the patient populations needs.

On the other hand, if specialists did want to connect to primary clinics, they may have lower revenue to support the initial investment into telehealth technology, being smaller and more specialized. These findings are somewhat substantiated by study 2 when multiple interviewed clinical staff noted issues in finding other providers to connect with. Primary care facilities struggled to find specialists that were ready, willing, and able to connect with them so that they can provide more services to their community. A few specialty clinics were not foreseeing growth as their demand was stable at the moment and administration was comfortable. Resources in study 2 that were lacking were not so much related to monetary resources as much as appropriate providers being available and gaining the proper technological connections.

Technology infrastructure is not just a facilitator or barrier of readiness to implement, it is also a facilitator or barrier to the ability to implement and sustain telehealth services. Greater technology infrastructure can lower the upfront costs of implementation, as there is already a system to build off. However, the barrier of malfunctioning technology that arose in study 2 can greatly hinder the ability of clinics to implement and continue to use telehealth technologies. Many extremely rural clinics still

use general broadband cable, and for telehealth providers who expect clients to use WiFi based carts, this is not a design that will be successful in these environments. Within this aspect of ability, we can also circle back to the clinic that ceased receiving teleradiology services from an outside provider. There was a lack of proper technology, so personnel were using more time attempting to use the technology, and the expected outcome was not being met by the provider of services. This may be due to a lack of ability of the clinic to have the proper technology infrastructure to make uploading images faster (slow internet connections, old computer systems, etc.). There may also have been a lack of ability of those providing the teleradiology services to properly design a system for their client or lack of radiologist on call to perform services in the timeframe expected by the client. Ability to access an innovation can be as simple as the ability to plan and design according to a facility's needs and be completely unrelated to monetary resources.

IV. Implications

One of the most glaring implications of conducting these studies are the lack of information there is about telehealth services on a local and national scale. The legitimization of telehealth services can only be proven with evidence on the extent and benefits of telehealth technology use. However, there is no standardization among organizations or state and federal governments on how to even define telehealth technologies. The overarching goal of this dissertation was to fully capture telehealth facilitators and barriers to meeting all three preconditions of RWA in relation to the CSTS hierarchical levels of domain ecosystem, system structure, delivery operations, and work practices. The introduction to these studies discussed the fit of telehealth

technology within traditional clinic practice. Bashur et al. (2013) noting that only when telemedicine is fully integrated as part of the normal clinical workflow, and not set aside as a unique niche service, will the full extent of benefits be achieved.[1]

To become sustainable as part of an organization, there must be a readiness to see the continued benefit of the technology's use, willingness to accept it as a normative process in the workflow, and the ability to maintain the services with available resources. Telehealth is growing, this can be heard in the interviews with Nebraska telehealth providers, but not only in Nebraska. The development of state and federal policies for reimbursement and the expansion of those policies suggest the need for equitable reimbursement for the growing number of services provided by some form of telehealth technology. However, there is a lack of any standardization in the way providers of telehealth are billing for these services and recouping the necessary funds to continue and sustain these services.

There are many hospitals and clinics that would implement telehealth services for their patients benefit yet they do not have the resources. One of those resources is people to connect with, other providers to network with and gain services that they could otherwise not provide. Every organization is unique in their needs, there may never be standardization in the technology and how it is used, but there needs to be some standard in networking between providers. The state licensure compacts hope to ease the burden of licensing telehealth providers across state lines, but there are still many hoops to jump through. Similarly, many hospitals and health systems have their own bylaws that may need to be changed to allow outside providers to network. Telehealth shakes the

foundation of traditional medical practice and requires changes to workflow processes and the healthcare culture.

As healthcare moves toward a system of wellness and prevention over sick care, there is greater demand for innovative ways to improve the quality of their services. Similarly, the population is living longer and is soon to see a boon in the proportion of the US population over the age of 65.[183] Chronic care management will be critical for healthcare organizations to meet quality indicators for patient care and reimbursement.[184] Yet at the same time the US is facing an ever-growing deficit in primary care physicians and behavioral health providers.[80] Telehealth has the capability to make the most of the providers that are practicing currently and in the near future and allows for equitable access for every person regardless of their location. An example of this from study 2 is a clinic that is in the process of becoming a patient-centered medical home, but they have only one nutritionist for 14 clinics. They have started using telehealth to allow the nutritionist to see more patients throughout the day and negated the need for the nutritionist to travel to clinics. This allows patients to have more flexibility with appointments as they are not confined to times when the nutritionist is at the clinic.

Correctly designed and implemented telehealth programs can gain healthcare organizations and their patients numerous benefits. Despite years of studies, there are still barriers to overcome to improve telehealth use within healthcare. One is gaining the resources and the knowledge to create a well thought out telehealth program that will meet the needs of that organizations. Many of the states have telehealth network websites, but the quality of these sites is variable.[185] Nebraska's statewide telehealth

network website has not been updated since 2013. The information provided on this website is no longer useful for those organizations seeking to network with other state providers.[186] There is the American Telemedicine Association, but there is only so much information you can access without being a member of the association.[187] Although there are these resources it requires healthcare providers to be aware of these resources and have time to explore them, with no guarantee they will provide a solution to the lack of resources for the organization.

Not all clinics have a designated telehealth coordinator or staff person that solely does telehealth related duties. These providers are often nurses or administrators that have many other duties they need to complete along with running the telehealth program. There needs to be a more substantial and helpful way to get information to providers to help them with finding resources such as grant funding and providers willing to network. Within this information, there needs to be standardized terminology so that everyone can communicate with understanding regardless of location. This is evident when you look at the AHA data where neither telehealth nor RPM is defined in their survey. When speaking to telehealth providers, I found that many did not understand the term telehealth, they only knew the term telemedicine. This is an issue when you are trying to better understand the current state of telehealth in the US.

There is also a need for standardization of evaluation of telehealth programs, how do you define the success of telehealth programs? Patient outcomes, revenue, or the number of patients seen. A standardization of evaluating success for telehealth programs would be difficult due to the variability in the forms of telehealth technology and how it

is being used within the clinic. However, there should be some template to aid healthcare organizations in evaluating their programs so that they can better understand what is succeeding and what needs a redesign. This is extremely important for those individuals who are not telehealth experts but run telehealth services as part of their clinical duties. This evaluation will also help to show the benefits of telehealth technology within healthcare, and continue to legitimize it in the eyes of healthcare providers and legislators.

Finally, as we move forward and more and more services are provided by telehealth technologies, there needs to be a way to collect data that is accurate and provides information on what telehealth is and how it is being used in the US healthcare system. The current data is limited and lacking accuracy; there is no way to fully analyze all the dimensions of telehealth that need to be understood to facilitate the implementation processes and improve telehealth programs. The largest implication of this dissertation is that technology is becoming pervasive and we need to be advancing in all aspects as quickly as the growth of innovation. Policy and processes should not be playing catch up to the diffusion of technology. There needs to be an understanding at every level to allow for adaptive adjustments that will facilitate organizations readiness, willingness, and ability to implement and sustain telehealth technologies.

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Appendix A: 2015 American Hospital Association Annual Survey Health Forum, L.L.C.

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Appendix B: 2015 AHA Annual Survey Information Technology Supplement Health Forum, L.L.C.

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Appendix C: HPTS 2017 Telemedicine Survey

To better understand the telemedicine services offered in Nebraska, we would appreciate your answers to the following questions. Thank you for your time.

A. Telemedicine services used by your facility

1. **Between patients and provider(s) in your facility** *(please check all that apply)*:
   - ☐ Live, interactive video consultations
   - ☐ Remote patient monitoring (RPM)
   - ☐ Store-and-forward consultations - *patient information, still images, remote monitoring of vital signs, records, etc. captured and forwarded to your facility for evaluation at a later time*
   - ☐ Hybrid consultations - both live, interactive and store-and-forward consultations are provided
   - ☐ Facility does not provide the services listed above

2. **Between professionals - Store-and-Forward** (*patient information, still images, records, etc. are captured and forwarded for evaluation at a later time) (please check all that apply)*:
   - ☐ Providers in your facility capture and forward patient information to other facilities for evaluation
   - ☐ Providers in your facility receive patient information from other facilities for evaluation
   - ☐ Facility does not provide the services listed above

3. **Telemedicine specialties provided or received** *(check all that apply):*
   - ☐ Primary Care
   - ☐ Behavioral Health/Psychiatry
   - ☐ Chronic Disease Management (diabetes, heart failure, hypertension, etc.)
   - ☐ Teleradiology
   - ☐ Other _____

B. What is your perception of barriers to implementing and maintaining telemedicine services

(check all that apply):

- ☐ Communication infrastructure (including broadband access)
- ☐ Cost to implement or maintain
- ☐ Credentialing in multiple facilities
- ☐ End-user technology comfort issues
- ☐ Licensing across state boarders
- ☐ Medical coding
- ☐ Reimbursement denial

- Reimbursement rates
- No interest or not a priority
- Other: _____

Thank you. We appreciate your time and responses.

Appendix D: HPTS 2017 Clinic and Provider Surveys

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