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HOME CARE QUALITY EFFECTS OF REMOTE MONITORING

by

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A dissertation submitted in partial fulfillment of the requirements  
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ABSTRACT

Despite concerted efforts to decrease costs and increase public health, the embattled U.S. health care system continues to struggle to alleviate these widespread issues. Because the problem of hospital utilizations among patients with heart failure is posited to increase as the population ages, innovative methodologies need to be explored to mitigate adverse events. Remote monitoring harnesses the strength of advanced information and communication technology to affect positive changes in health care quality and cost. By reaching across geographical boundaries, remote monitoring may support increased access to less costly services and improve the quality of home health care.

The purpose of the study was to examine the home care quality effects of remote monitoring technology in patients with heart failure and to provide an economic justification for its adoption and diffusion. It compared remote monitoring as a potential intervention strategy to a standard no-intervention group (without remote monitoring). Specifically, it analyzed remote monitoring as a viable strategy to decrease hospital readmissions and emergency department visits. It also compared the cost of remote monitoring against the current standard-of-care.

The theoretical framework of Donabedian’s Quality Model was used in the evaluation of remote monitoring. A retrospective posttest only, case control study design was used to test the degree which remote monitoring was effective in promoting health care quality (hospital readmissions and decreased emergency department visits). Retrospective chart reviews were performed using electronic medical records (EMR). Analysis of Variance, Path Analysis, Automatic Interaction Detector Analysis (Dtreg), and Cost Outcomes Ratio were used to test the hypotheses and validate the proposed theoretical model.
No significant difference was noted in remote monitoring and usual care groups. Results suggested that remote monitoring does not statistically lead to a decrease in heart failure-related hospital readmissions and all-cause emergency department visits. Results of the cost ratio analysis suggested that there was no statistically significant difference in the net income between usual care and remote monitoring; however, data suggest that there were significant increases in cost and intensity of nursing utilization for the remote monitoring intervention. The Automatic Interaction Detector Analysis showed that the unfavorable results in hospital readmissions were due to a decrease in collaborative care and patient education prior to the recommendation for hospitalization.

The role of nursing care, whether in hospital or community-based care, in heart failure management is critical to quality outcomes. As the field continues to consider the use of technology in health care, decision makers should think through the process of patient care such that preventable hospital readmissions are decreased and patients received quality care.
This dissertation is dedicated to my husband, Alonzo, whose steadfast support and sacrifice has propelled me to completion. To my boys, Trey and AJ, whose hugs and kisses were great reminders of the incredible family I am so blessed to be apart of.
ACKNOWLEDGMENTS

John Stuart Mill once said that “a pupil from whom nothing is ever demanded which he cannot do, never does all he can”. I am truly grateful for the countless hours of instruction and constructive criticism that has expanded my personal, professional, and academic growth. This dissertation is the result of an incredible amount of support and guidance from a group of academic professionals to whom I am indebted.

My heartfelt appreciation to my committee chair, Dr. Wan, for your mentorship; you have truly enriched my academic experience. Thank you for encouraging my research interest and broadening my ability to think critically about health policy research. Your leadership has propelled me to this moment and into new opportunities for growth. Dr. Ning Jackie Zhang, your commitment to excellence and methodological rigor in research is unmatched. Your dedication to my learning and discovery through research has encouraged my novice skills. Dr. Dawn Oetjen, I have the awesome privilege of working with you the longest - 11 years. I cannot say enough about your leadership through the years, your encouraging words were so valuable throughout my courses of study. Dr. Mary Ann Burg, for the many hours you invested in my career growth and academic planning, I am grateful. Thank you for investing in me personally and going to extra mile to promote my academic goals.
# TABLE OF CONTENTS

LIST OF ABBREVIATIONS ........................................................................................................ xii

CHAPTER ONE: INTRODUCTION ......................................................................................... 1
  Statement of the Problem ........................................................................................................ 1
  Heart Failure ......................................................................................................................... 2
  Quality Challenges ............................................................................................................... 4
  Current Standard of Care .................................................................................................... 6
  Remote Monitoring Technology .......................................................................................... 6
  Purpose of the Study ............................................................................................................ 8
  Research Questions ............................................................................................................. 8
  Significance of the Study ...................................................................................................... 9
    Structure and Process ........................................................................................................ 20
    Process and Outcomes ....................................................................................................... 23
    Interaction of Structure and Process on Outcomes ......................................................... 26

CHAPTER THREE: METHODOLOGY ................................................................................ 30
  Study Instrument ................................................................................................................ 30
  Study Variables .................................................................................................................. 31
  Sampling .............................................................................................................................. 35
  Clinical Procedures .......................................................................................................... 37
  Data Collection and Handling ............................................................................................ 40
  Statistical Analysis Plan ..................................................................................................... 40
  Propensity Score Matching and Analysis .......................................................................... 41
  Data Analysis ..................................................................................................................... 43
  Donabedian Process Analysis: Dtreg ............................................................................... 44
  Cost Outcomes Ratio .......................................................................................................... 45
  Hypothesis Testing ............................................................................................................. 47
  Chapter Summary .............................................................................................................. 48

CHAPTER FOUR: RESULTS ................................................................................................ 50
  Propensity Score Matching and Analysis .......................................................................... 50
  Descriptive Statistics ......................................................................................................... 50
Analysis of Variance ................................................................. 51
Path Analysis ............................................................................ 55
Automatic Interaction Detector Analysis: Process ....................... 65
Structural Equation Modelling ................................................... 69
Cost Outcomes Ratio ................................................................. 75
Chapter Summary ..................................................................... 79
CHAPTER FIVE: DISCUSSIONS AND CONCLUSIONS ................... 81
Results of Hypothesis Testing .................................................... 81
Significance of Results and Theoretical Importance .................... 85
  Structure and Process ............................................................. 85
  Process and Outcomes ............................................................ 85
  Interaction of Structure and Process on Outcomes ................... 86
Practical Use ............................................................................. 87
Policy Relevance ....................................................................... 89
Methodological Rigor ............................................................... 90
Limitations ............................................................................... 91
Recommendation for Future Research ....................................... 92
APPENDIX A: SIGNIFICANCE OF HOSPITAL READMISSIONS ....... 95
APPENDIX B: SUMMARY OF INFLUENCE OF HEART FAILURE ...... 97
APPENDIX C: SUMMARY OF THE LITERATURE OF REMOTE MONITORING EFFECTS ON QUALITY ................................................. 99
APPENDIX D: SUMMARY OF COST ANALYSIS OF REMOTE MONITORING .......... 102
APPENDIX E: OPERATIONALIZATION OF STUDY VARIABLES .......... 104
APPENDIX F: SUMMARY OF HEALTH LEGISLATION TO SUPPORT HEALTH QUALITY AND TECHNOLOGY USE .............................................. 107
APPENDIX G: OASIS DATA SET INCLUDED IN THIS STUDY .......... 110
APPENDIX H: SUMMARY FOR REASONS FOR HOSPITAL READMISSIONS .... 119
APPENDIX I: DESCRIPTIVE RESULTS OF INTENT TO TREAT FOR REMOTE MONITORING ................................................................. 123
APPENDIX J: COST OUTCOMES OF USUAL CARE ......................... 125
APPENDIX K: COST OUTCOMES OF REMOTE MONITORING .......... 127
APPENDIX L OPERATIONALIZATION OF STUDY VARIABLES FOR THE INTERACTION EFFECT OF STRUCTURE AND PROCESS ON OUTCOMES ............ 129
APPENDIX M: INSTITUTIONAL REVIEW BOARD APPROVAL ............. 131
LIST OF CITED REFERENCES ........................................................ 133
LIST OF FIGURES

Figure 1. Donabedian Quality Model: Structure, Process & Outcomes .................................................. 10

Figure 2 The Conceptual Framework for the Donabedian Quality Model .............................................. 21

Figure 3. Diagram of the Influence of Structure on Process of Heart Failure ......................................... 22

Figure 4. Diagram of Process of Care Relationship to Outcomes for Visiting Nurses .............................. 25

Figure 5. Diagrammatic Representation of the Interaction of Structure and Process on Outcomes .............. 26

Figure 6 Diagrammatic Summary of Remote Monitoring Procedures ..................................................... 37

Figure 7 Summary of Information Processing for Remote Monitoring .................................................. 39

Figure 8 Results of Match Covariates after Propensity Score Analysis .................................................. 50

Figure 9 Proposed Path Analysis on the Predictors of Hospital Readmission ......................................... 56

Figure 10 Revised Path Analysis of the Predictors of Hospital Readmission ......................................... 58

Figure 11 Proposed Path Analysis on the Predictors of Emergency Department Visits ............................. 60

Figure 12 Revised Path Analysis of the Predictors of Emergency Department Visits ............................... 61

Figure 13 Graph of Heart Failure Symptoms and Heart Failure Hospital Readmissions .......................... 63

Figure 14 Plot of Pretest and Posttest of Dyspnea across Remote Monitoring Intent to Treat .................. 64

Figure 15 Dtreg Analysis of the Effects of Clinical Decision-making on Hospital Utilization .................. 68

Figure 16 Proposed Measurement Model of Structure and Process ......................................................... 70

Figure 17 Revised Measurement Model of Structure and Process .......................................................... 71

Figure 18 Proposed Measurement Model of Health and Cost Outcomes ............................................... 72

Figure 19 Revised Measurement Model of Health and Cost Outcomes ............................................... 73

Figure 20 Proposed Measurement Model of the Structure and Process Influence on Outcomes ............... 74
LIST OF TABLES

Table 1. Summary of Heart Failure Classifications ................................................................. 4
Table 2 Questions from Remote Monitoring Program ............................................................. 39
Table 3 Descriptive Statistics for Usual Care and Remote Monitoring Groups ....................... 51
Table 4 Summary of Descriptive Statistics for Heart Failure-related Hospital Readmissions .... 53
Table 5 Summary of ANOVA Results of Heart Failure-related Hospital Readmissions .......... 54
Table 6 Goodness of Fit Statistics for Heart Failure-related Hospital Readmissions .......... 57
Table 7 Standardized Estimates of the Revised Path for Heart Failure-related Hospital
Readmissions .......................................................................................................................... 57
Table 8 Goodness of Fit Statistics for All Cause Emergency Department Visits ................. 61
Table 9 Standardized Estimates from the Revised Model of All Cause Emergency Department
Visits ......................................................................................................................................... 62
Table 10 Summary of Results of Descriptives of HF Symptoms ........................................... 63
Table 11 Summary of ANOVA Results ................................................................................... 63
Table 12 Summary of Results of Key Statistical Assumptions ............................................. 65
Table 13 Summary of Descriptive Statistics for Intent to Treat and Dyspnea ....................... 65
Table 14 Results of the Automatic Interaction Detector Analysis Dtreg ................................. 69
Table 15 Summary of Standardized Estimates of Structure and Process Model ................. 71
Table 16 Goodness of Fit Statistics for Structure Process Model ........................................ 72
Table 17 Summary of Standardized Estimates of Health and Outcomes Model .................. 73
Table 18. Summary of Goodness of Fit Statistics of Outcomes Model ................................. 74
Table 19 Summary of Standardized Estimates of Structure and Process Influence on Outcomes

Table 20 Summary of Average Annual Remote Monitoring Program Cost

Table 21 Summary of Results of Independent T Test for Remote Monitoring

Table 22 Summary of Hypothesis and Results

LIST OF ABBREVIATIONS

AGFI  Adjusted Goodness of Fit Index
AID Automatic Interaction Detector Analysis: Dtreg
ALF  Assisted Living Facility
AMOS Analysis of Moment Structure
CA  Clinical Acuity
CMS Center for Medicare and Medicaid Services
COPD Chronic Obstructive Pulmonary Disease
ED  Emergency Departments
FA  Functional Acuity
GFI  Goodness of Fit Index
HA  Hospital Readmissions
HA TIF Hospital Readmissions due to Heart Failure
HF  Heart Failure
HHRG Home Health Reimbursement Group
HIT Health Information Technology
IRB Institutional Review Board
ITT Intent to Treat
MD  Medical Doctor
OASIS Outcomes and Assessment Information Set
PPACA Patient Protection and Affordable Care Act
PSM  Propensity Score Matching
QUALY Quality Adjusted Life Years
RMSEA Root Mean Square Error of Approximation
SE Social Environment
SEM Structural Equation Modeling
SNF Skilled Nursing Facility
SPO Structure Process Outcome
SPSS Statistical Package for Social Sciences
SS Social Support
TIF Transfer to Inpatient Facility
CHAPTER ONE: INTRODUCTION

Statement of the Problem

The complexities of the health care environment are exacerbated by escalating health care costs and decreasing quality. Characterized “as the world’s most expensive yet least effective [as] compared with other [nations’ health care system], [the] growing health care costs have made millions of citizens vulnerable” (Kumar, Neha, & Shah, 2011, p. 366). The economic challenges facing the United States are confounded by the unprecedented growth in health care spending. This growth is attributed to an increase of chronic diseases and the use of costlier services. This study highlights the public health and economic crisis confronting the U.S. population.

The escalating cost of health care is unsustainable. In spite of the recent economic downturn, health care spending continues to increase (Roehrig, 2011). Data obtained from the Center for Sustainable Health Spending stipulated that, since 1990, the health care share of the GDP has risen significantly from 12 to 18 percent (Roehrig, 2011). Estimated expenditures in FY 2010 were estimated to be $2.6 trillion, about 18 percent of GDP or $8,402 per person (Tompkins & Orwat, 2010).

In addition to the rising cost of care, there was a concomitant increase in the population age. From 2000 to 2010, persons aged 45–64 years grew 31.5 percent to 81.5 million, about 26.4 percent of the total population (“2010 Census Shows Nation's Population is Aging,”). The older adult population, persons age 65 and older, also experienced fast growth rates. Growth rates were estimated at 15.1 percent (40.3 million members) or 13.0 percent of the total population (“2010
Census Shows Nation's Population is Aging, "). By 2025, it is predicted that this age group will have over 1.2 billion members, or 35 percent of the total population (Bloom & McKinnon, 2010; Wei-lun, Soe-Tsyr, & Li, 2009).

The demographic change was due to several reasons. In the 1950s and 1960s, there were dramatic increases in births; seventy-eight million people were eligible for retirement in 2008. Secondly, due to advances in technology and medicine, life expectancy is expected to increase. In 2010, life expectancies for males and females were 75 years and 80 years, respectively. This change represents a 35 percent and 30 percent increase over the last 60 years for males and females, respectively (Kilgour, 2010). Although these numbers are positive, it presents a challenge for a health care system with rapidly depleting resources.

This sector of the population uses the greatest amount of health care resources. Martini et al. (2007) suggest that most of the health care costs are attributed to those that are 75 years and older. It was estimated that in 2003, the total health care cost for the U.S. was $183 billion (Hussain & Rivers, 2009). By 2050, costs for older adults are projected to be $379 billion (Hussain & Rivers, 2009). These data require that society make significant changes in how it cares for older adults.

**Heart Failure**

Heart failure (HF) remains one of the most prevalent and costly diagnoses among older adults (Polisena et al., 2010). The life time risk of developing HF is 20 percent and increases exponentially with age. The prevalence rate is 20 per 1000 individuals at 65 to 69 years of age and 80 per 1,000 individuals at 85 years and older (Yancy et al., 2013).
The American College of Cardiology and the American Heart Association define HF as a “complex clinical syndrome that results from any structural or functional impairment of ventricular filling or ejection of blood” (Yancy et al., 2013, p. 1500). Heart failure refers to the inability of the heart to adequately meet the body’s needs for metabolic function (Tansey, 2010). The cardinal symptoms of HF are dyspnea and fatigue. The most prevalent sign is fluid retention, which may lead to pulmonary or peripheral edema and manifest itself as weight gain (McMurray, 2010; Yancy et al, 2013). The inability of the heart to properly function may be due to myocardial infarction, hypertension, malfunctioning of one of the linings of the heart, or one of the great vessels (Tansey, 2010). Most patients diagnosed with HF have symptoms due to left ventricular myocardial infarction (Yancy et al., 2013). Patients with HF may be asymptomatic, accounting for 6 to 21 percent of the population and increases with age (Yancy et al., 2013). Diagnosis of heart failure is made in light of patient history, findings on examination, and diagnostic tests (McMurray, 2010). Patients may be classified according to the New York Heart Association Functional Classification Scale or the American Heart Association (AHA)-American College of Cardiology Classification Scale (see table 1) (McMurray, 2010).

Many times heart failure goes undiagnosed, delaying the need for timely medical care. This results in poor health quality and the inability to proactively treat manageable symptoms. The goals of HF management programs are to reduce the symptoms, mitigate the need for hospitalizations, and the prevention of premature death (Lee, & Moser, 2013; McMurray, 2010). Therefore, the effectiveness of any technology-oriented intervention program would support the clinical process of providing effective and efficient care.
Table 1. Summary of Heart Failure Classifications

<table>
<thead>
<tr>
<th>Class</th>
<th>New York Functional Classification Scale</th>
<th>AHA – American College of Cardiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>No functional limitation with ordinary activity; no signs and symptoms</td>
<td>Stage A; High risk, no signs and symptoms, no functional or structural deficits</td>
</tr>
<tr>
<td>Class II</td>
<td>Mild functional limitation with mild signs and symptoms with ordinary activity. Comfortable at rest</td>
<td>Stage B; Structural deficits indicative of heart disease with no signs and symptoms</td>
</tr>
<tr>
<td>Class III</td>
<td>Significant functional limitations with signs and symptoms with less than ordinary activities; comfortable at rest.</td>
<td>Stage C; Symptomatic heart disease with underlying structural deficits</td>
</tr>
<tr>
<td>Class IV</td>
<td>Unable to perform functional activities without undue discomfort; symptoms present at rest.</td>
<td>Stage D; Advanced structural deficits with marked functional limitations despite medical interventions</td>
</tr>
</tbody>
</table>

**Quality Challenges**

Heart failure is the most common cause for hospitalizations among persons aged 65 years and older (Jerant, Azari, & Nesbitt, 2001). The risk of HF increases exponentially with age and continues to rank as the most frequent cause of hospitalizations (Chen, Normand, Wang, & Krumholz, 2011; Eriksson, 1995). Although longitudinal studies indicated that aggregate hospitalization rates have decreased since 1999, HF continues to have a sizeable impact (Chen et al., 2011). The quality challenges are reflected in high hospital utilizations, mortality rates, and increased costs of care. Hospital utilizations included hospital readmissions and emergency department visits.

Hospital Readmissions. Hospital readmissions represent a significant portion of Medicare costs. Previous research shows that the numbers of hospital readmissions among older adults are staggering. Repeated hospital admissions due to poor chronic care management account for much of the costs. Hospital readmissions rose 26 percent from 1996 to 2006 (Ballard et al.,
In 2004, unplanned hospital readmissions cost Medicare $17.4 billion, out of $102.6 billion in total hospital payments (Jweinat, 2010). This cost represented 20 percent of all Medicare beneficiaries that were readmitted to the hospital within 30 days of discharge and 34 percent within 90 days of discharge.

Mortality. Despite pharmacological and technological advances in health care, heart failure is associated with poor survival (Robertson et al., 2012). Fifty-nine percent of men and 40 percent of women die within five years of the diagnosis of heart failure (Lloyd-Jones et al., 2010). One in ten patients die within 30 days of diagnosis and, of those who survive, one in four has a high number of readmissions (Joynt, Orav, & Jha, 2011). The median survival rate after heart failure readmission was 1.5 years for individuals over the age of 85; three years for those 80 to 85 years of age; and four years or greater for individuals less than 79 years of age (Robertson et al., 2012). The current status of hospital readmission necessitates watershed strategies by legislators, health care administrators, and clinicians. The lack of quality care is highlighted by the high number of mortalities.

Costs. Due to escalating costs, chronic care coordination is a national health priority (Buntin, Jain, & Blumenthal, 2010). Ding, Yehle, Edwards & Griggs, (2013) estimated that the cost of HF will increase from $31 billion in 2012 to $70 billion in 2030. Heart failure symptoms account for 16 percent to 24 percent of readmissions and respiratory ailments for 11 percent to 20 percent (Epstein, Jha, & Orav, 2011). According to Epstein et al., (2011), other diagnoses contributed no more than six percent combined.
**Current Standard of Care**

Home health care provides post-acute interventions to alleviate the exacerbation of chronic diseases. Patients are eligible to receive home health care services as long as they remain homebound and able to demonstrate reasonable progress in clinical and functional status (Riggs & Madigan, 2012). Objectives in home health care are to restore maintenance and/or improve functioning. Current standards of care include education in self-care management of symptoms, pharmacological interventions, and nursing interventions (Eriksson, 1995). The presence of comorbidities increases the difficulty of self-care management by the patient and the health care practitioners (Eriksson, 1995). Therefore, remote monitoring is proposed as a strategy to increase the frequency of clinical interactions.

**Remote Monitoring Technology**

Remote monitoring is a relatively new use of technology that is currently being considered to affect positive change in health care quality. It combines advanced information communication technologies and commercialized biometric sensor devices to address disease management at a distance, thus facilitating health status monitoring (Chen et al., 2012). Remote monitoring allows users to be monitored in their preferred living environment with equipment that transmits health information to/from the patient and to/from the care provider (Sorell & Draper, 2012). The exchange of valid health information is used for “diagnosis, treatment, and prevention of disease, evaluation, research, and for continuing education of health care providers; all in the interest of advancing the health of individuals and their communities” (Maeder, 2010, p. 239). As an advanced method of information and communication technology,
remote monitoring has the potential to change health care delivery, but requires sufficient patient support and multidisciplinary collaboration (Bos, Carroll, & Marsh, 2008). Health information must be presented to the patient and clinical team to support decision making (i.e. the right information should be presented at the “right time,” without requiring undue effort) (Bos et al., 2008, p. 2).

Remote monitoring may promote quality outcomes by alerting health care professionals of early warning signs and enabling proactive alleviation of potentially deteriorating conditions. Advances in telecommunication technology provide information that may assist in early detection and intervention of acute exacerbations; mitigation of complications from chronic diseases, and the reduction of preventable hospital readmissions (Anker, Koehler, & Abraham, 2011). It enhances information integration and analysis, thus, it converts information into knowledge and identifies opportunities for effective intervention (Nobel & Norman, 2003). The remote monitoring system offers a way in which specific physiological information is electronically transferred to a health care professional (Anker et al., 2011). Through continuous feedback mechanisms, remote monitoring can enhance communication efforts by allowing clinicians to make assessments based upon accurate and timely information. This system supports the use of evidence-based decision making to promote positive patient outcomes.

Remote monitoring service models use information and communication technologies to provide remote health care services to decrease health care costs and improve quality (Li, Wang, Lu, Lin, & Yen, 2012). They are able to overcome geographical barriers between health care professionals and patients (Anker et al., 2011). Telehome care is defined as the “provision of care, instruction, and education to patients in their place of residence using telecommunication
technologies” (Britton, Engelke, Rains, & Mahmud, 2000, p. 27). Remote monitoring supports the ability to send data “between participants that are physically separated for the purposes of clinical care” (Lockamy & Smith, 2009).

The use of remote monitoring in the home care environment is a growing trend in healthcare (Gagnon et al., 2009). Home remote monitoring, the use of telecommunication technologies to monitor patients at home, has received considerable consideration as an acceptable method of care delivery (Takahashi et al., 2010). Remote monitoring technology is being employed by many home health agencies to aid in the management of chronic diseases (Cardozo & Steinberg, 2010).

**Purpose of the Study**

The purpose of the study was two-fold: (1) to examine the home care quality effects of remote monitoring in patients with HF, and (2) to analyze its cost effectiveness. Specifically, it examined the potentials, if any, of remote monitoring as a cost-effective alternative to decrease hospital readmissions and emergency department visits as compared to the comparison group under current standards of care.

**Research Questions**

1. To what extent does the cost per outcome justify the use of remote monitoring in patients with HF?
2. To what degree is remote monitoring in home care used to affect positive change in the process of care?
3. In an effort to decrease the costs of accessible quality care, can remote monitoring be used as an intervention strategy to affect positive changes in health and cost outcomes among patients with HF?

**Significance of the Study**

As the problem of hospital utilizations among older adults with heart failure is posited to increase as the population ages, innovative technologies need to be explored to mitigate adverse events. This study added to the body of knowledge on the degree to which remote monitoring may affect positive change in the health care system. Thus, it provides evidence that may demonstrate the viability and sustainability of remote monitoring as a home care modality for patients with HF.
CHAPTER TWO: LITERATURE REVIEW

Theoretical Framework

The current status of health care has led to the consideration of innovative strategies to include remote monitoring. However, due to resource constraints, merely trying out a new idea to see if it works is not an adequate option (Christensen & Raynor, 2003). The medical and economic environments of many health care organizations deem that too much is at risk. Therefore, a sound theoretical framework should guide the possible adoption, utilization, and evaluation of remote monitoring. The Donabedian Quality Model was highlighted in this study to facilitate the discussion of remote monitoring as an intervention program for home care patients. Donabedian, a pioneer in health care quality research, developed a framework for quality improvement (Donabedian, 2005; Glickman, Baggett, Krubert, Peterson, & Schulman, 2007). It is under his theory of structure-process-outcomes relationships, that Donabedian provides guidance for the provision and evaluation of quality of patient care. The assumption of Donabedian’s Model is that there is a positive correlation between structure and process and process and outcomes (see Figure 1) (Qu, Shewchuck, Chen, & Richards, 2010). This study will also consider an interaction of structure and process on outcomes.

Figure 1. Donabedian Quality Model: Structure, Process & Outcomes.
Donabedian: Structure

Donabedian’s concept of structure suggests that given the proper framework and tools, adequate medical care will follow (Donabedian, 2005). In home health care, the influence of social structure and social environment varies between patients. Remote monitoring provides an additional structural framework to support medical care. This technological infrastructure provides a platform in which available medical resources in the form of telephone support and physiological data can be facilitated and shared. Thus, in the home environment, technology and the socio-environmental context are inherently inseparable (Orlikowski & Scott, 2008).

“[Technology] is a tool . . . it does not ‘represent’ the work, but it feeds into it, it structures it in complex ways: it structures communication between health care personnel, shapes medical decision-making, and frames relationship between personnel and patients” (Berg, 1998, p.27). From the provider’s perspective, it is a means to facilitate collaborative care. Home care clinicians provide direct care in a relatively autonomous environment and opportunities to collaborate with team members are reduced. Therefore, a structure that enhances the process of collaborative care by promoting more meaningful interdisciplinary interactions is important in a clinically supported environment.

Current structures for care are embedded in routines and repetitive actions across multiple actors to deliver care (Goh, Gao, & Agarwal, 2011). Structures and routines are used to ensure quality through standard operating procedures. Goh et al., (2011) find that enhancing routines via health information technology can decrease redundancy and increase efficiencies. When remote monitoring enters into health care, it changes the possibilities for clinicians to provide care due to the opportunities for interactions (Goh, Gao, & Agarwal, 2011).
Technology is potentially effective in overcoming geographical and physical barriers to medical care. Remote monitoring is currently being examined as a means to reduce health disparities for persons living in rural areas (Brooks et al., 2013). In the provider-patient relationship, remote monitoring would act as an intermediary between face-to-face visits. De, Gargaro, Sciarra, De, Zuccaro, Stirpe, & Calo, (2011) suggested that remote monitoring is more effective in detecting adverse events than intermittent office visits. The literature also indicates that remote monitoring technology allows health care information to be transmitted more frequently than would be permitted by face-to-face visits. This technology allows for an early detection of physiological deterioration that would otherwise not occur unless a clinician is physically present (Coughlin et al., 2006).

**Donabedian: Process**

The process of care refers to the application of information received from remote monitoring. Cooper and Zmud, as stated in Schwieger et al., (2004), reiterate that effectiveness is the “ability to take full advantage of the information technology being implemented” (p.239). This definition goes beyond the mere adoption of technology and seeks efficient application to demonstrate meaningful use. It also includes the application of technology outcomes; in other words, the information gained through the technology application process should be applied in the process of clinical care. In this study, the process of care occurs at two levels once symptoms are recognized: telephone support and face-to-face visits. Ideally, remote monitoring decreases the complexity of care by resolving physiological deterioration in HF status via telephone
support. At this level, remote monitoring has successfully led to desired outcomes. However, if face-to-face visits are required, then the process of clinical decision-making must occur.

Decision-makers use the information to “perceive, process, and respond” to affect change in health status (Astley & Van de Ven, 1983, p. 248). Decision-making in health care is the “process whereby the patient and the clinician have access to accurate information and time to elicit each other’s view so that they can come to a shared understanding of the best plan of action . . .” (Bryant, 2012, p. 38). The resulting clinical decision guides the plan of care and the strategy for implementing such care (Donabedian, 1983). Decision-making occurs in clinical collaboration and patient-provider interactions.

Clinical Collaboration. Technological tools enhance coordination and continuity of care by increasing information exchange between providers and organizations to affect patient-level care (Kazandjian & Lipitz-Snyderman, 2011). As a communicative tool, it brings “knowledge and expertise to the patient’s location” and narrows the knowledge gap between providers (Nilsen, 2011, p.1148). The ability for more synchronous exchange of information allows health care providers greater access clinical data, thus allowing clinicians to collaborate more effectively with a greater degree of information.

Narrowing this knowledge gap has been suggested to improve quality care (Benham-Hutchins & Effken, 2010; Nilsen, 2011). A study by Dendale and colleagues (2011) examined remote monitoring facilitated-collaboration and its effect on hospital readmission, cost, and mortality rate. This study found that collaboration supported by remote monitoring technology allowed practitioners to use the physiological data (i.e. blood pressure, weight, pulse, temperature) to focus on more at-risk patients (Dendale et al., 2012). The study’s results also
suggested that collaboration amongst professionals decreased mortality, hospital readmissions, and associated health care costs (Dendale et al., 2012). Participants attributed favorable results to increased information exchange. De et al. (2011) suggested that in patients with heart failure, remote monitoring provided data that established reliable predictors of adverse events. Practitioners used this information to enact early interventions and decrease the severity of symptoms.

Patient-Provider Interactions. Information technology enlists a critical component of health care—the patient. Patient involvement in their own care is critical to quality outcomes. Thus, supporting Cleland and Ekman (2010) description of patients as the “largest health care workforce available” (p. 1382). Improving the long-term outcomes of public health depends on the ability of this group to be active, confident participants in the pursuit of personal health. As an intervention strategy, information technology can be used to empower patients, increase self-efficacy, and promote adherence to treatment programs. Technology systems can send motivational messages to support current adequate self-care management behaviors and increase their understanding of disease management (Cleland & Ekman, 2010). Increasing self-confidence in self-care leads to better outcomes (Cleland & Ekman, 2010). Using the Self-care of Heart Failure Index and the Minnesota Living with Heart Failure Questionnaire, Buck and colleagues (2012) suggested a positive relationship between confidence in self-care and quality of life. Their findings suggested that self-efficacy affects the level of performance and participation for self-care activities.

Collaboration with patient and informal caregivers promotes learning and has potential to improve the quality of care and overall health (Brown, Scott Poole, & Rodgers, 2004).
Patients may deny symptoms, fail to recognize decline, delay in seeking medical advice, or seek medical advice prematurely. Patient education of signs and symptoms of a deteriorating condition is important to improve health outcomes (Peirce, Hardisty, Preece, & Elwyn, 2011). An Otera-Sabogal et al. (2010) study demonstrated that a proactive, educational approach statistically improved blood glucose levels, cholesterol, and the overall control of ailments in the study’s participants. West, Lagua, Trief, Izquierdo, and Weinstock (2010) found that 68 percent of behavioral goals were met or improved through the use of remote monitoring. This finding suggested that not all patients are passive participants in remote monitoring, but are rather engaged in personal health care. However, one criticism of remote monitoring was that technology increased the layer between physicians and clients (Nguyen, Kahn, & Angus, 2010). The current health care system operates in a fast-paced environment, with a high degree of uncertainty and an expanding knowledge base, and remote monitoring may add a layer of complexity unless partnerships are adequately established.

**Donabedian: Outcomes**

The field is considering the addition of a technological framework to support decision-making (the process of providing clinical care) to promote quality outcomes. The outcome of care is conceptualized in terms of recovery and restoration of function (Larson & Muller, 2002). Outcomes are influenced by the degree to which valid information is gained and effectively implemented to achieve a stated purpose (Schwieger, Melcher, Ranganathan, & Wen, 2004). Donabedian’s framework posits that a positive relationship between structure and process will
have a significant influence on patient outcomes (Larson & Muller, 2002). His framework views structure and process as precursors to favorable quality outcomes.

Quality refers to the avoidance of harm and the optimization of clinical care given adequate resources to affect the greatest possible health benefit (Donabedian, 1983). Quality may be conceptualized in this study as decreasing the need for hospital utilization. Appropriate care refers to the point at which the expected health benefit exceeds the expected negative consequences ("Evaluating the effects of remote monitoring on quality, access, and cost," 1996). Appropriate care improves the clinical effects of remote monitoring. The high rate of hospital utilizations is reflected, in part, on the failure of the health care system to provide quality care. Those who support remote monitoring envision it as a strategy that can aid in monitoring chronic diseases before hospital utilization is necessary.

Clinical Outcomes. A literature review by Stuti et al., (2009) found that more studies showed a positive effect on clinical outcomes, but the proposed cost efficiencies of advanced remote monitoring were not empirically supported. Jerant et al.’s., (2001) finding suggested that while distance technology can improve hospital readmissions, emergency visits, and cost of care for patients with HF, home remote monitoring did not offer statistical significant benefits beyond that which was offered by telephone follow-ups and was more expensive (Jerant et al., 2001).

A Wakefield et al., (2012) study examined clinical outcomes in patients with diabetes and hypertension, using a comparison group and two levels of intensity of remote monitoring. The findings suggested that while clinical outcomes improved, as demonstrated by positive results with A1C levels, there was no statistically significant difference among the groups. Patient self-report of self-efficacy was also not statistically significant. Another study examined clinical
outcomes in patients with chronic obstructive pulmonary disease (COPD) and suggested that remote monitoring was not statistically significant between the intervention group and the control group (Darkins & Sanders, 2009). Pulmonary function tests were favorable in both groups; however, this data set suggested remote monitoring was not statistically influential and noted minimal change in quality of life.

Hospital Utilization. The current interest in remote monitoring technology lies in its potential to decrease preventable emergency department visits and hospital readmissions. A New Jersey study found that remote monitoring promoted a decrease in hospital readmissions by 14.93 percent ("Home remote monitoring cuts cardiac readmissions," 2011). Home remote monitoring was also supported by Antonicelli et al. (2010), whose findings suggested that the use of remote monitoring decreased hospital readmissions versus the control group (9 ver 26, respectively, p<0.05) (Antonicelli, Mazzanti, Abbatecola, & Parati, 2010).

Economic Quality. Quality may also be conceptualized as economic quality. Donabedian addressed the concept of cost in terms clinical efficiency and production efficiency. (Hahs-Vaughn & Onwuegbuzie, 2006). Clinical efficiency refers to the provision of the most efficacious intervention strategy given a specified amount of money (Donabedian, 1983). Production efficiency refers to cost associated with the production of care (Donabedian, 1983). Donabedian et al. (1982) stipulated that improvements in production efficiency allow one to achieve the same quality of care at decreased costs. This suggests that one can either improve the quality of care without increasing cost, or reduce cost without decreasing quality. The use of remote monitoring in health care seeks to optimize concomitantly clinical and production efficiency (Donabedian, 1983).
Proponents of remote monitoring tout its medical and economic propensity to reduce health care costs by decreasing hospital admissions and mitigating adverse events, therefore reducing emergency department use (Stuti, Susan, & Geetanjali, 2009; Whitten et al., 2002). A cost minimization study revealed that the principal source of savings from remote monitoring was derived from decreased hospital readmissions (64 percent) (Johnston, 2000). Other cost savings were noted in home care costs and technology programs, five percent and 53 percent, respectively (Johnston, 2000). The consensus of literature on the topic would appear to indicate that cost reductions were attributed to a reduction in hospital expenditures and indirect patient costs, such as travel costs (Seto, 2008).

Cost Outcomes Ratio. Cost Outcomes Ratio analysis assists in providing the best alternatives for care and has significant implications for the justification of allocating limited resources to support remote monitoring. By comparing alternate intervention programs, one assesses the relative efficiency and effectiveness of one program over another. Cost Outcomes Ratio is used to aid health care professionals, administrators, and public health officials in comparing the costs of various optional interventions with expected health gains (DePanfilis, Dubowitz, & Kunz, 2008). This comparison is used when one is measuring the remote monitoring of patients against the use of current standards of care.

A meta-analysis indicated unfavorable outcomes in emergency department visits, hospital readmissions, hospital length of stay, and cost (Clarke, Shah, & Sharma, 2011). The cost of care was not justified in the remote monitoring group (Takahashi et al., 2010). Takahashi et al. (2010) suggested that the remote monitoring group had an estimated cost of $14,678 and the control group was $10,161. However, the lack of cost accounting measures led to a poor economic
evaluation of remote monitoring (Takahashi et al., 2010). Appendix D provides a summary of
the paucity of carefully designed economic studies in regards to remote monitoring.

Skilled Nursing Visits. Current trends in home care show increases in service utilization.
Center for Medicare and Medicaid Services (CMS) estimated that in 2008 total home care
spending was $65 billion. The National Association of Home Care’s 2009 report indicated that
approximately 18.4 billion homecare visits were made in 2009, an average of 36 visits per
patient and approximately $146 per patient visit (Thompson, 2012). Dansky et al.’s (2001) study
proposed that home health agencies can economically benefit from remote monitoring by
offsetting the cost of remote monitoring programs by decreasing home visits. This method allows
agencies to provide more patient encounters while decreasing actual home visits/contact time
(Dansky, Palmer, Shea, & Bowles, 2001). This study supported the Kaiser Permanente study that
sets forth that the cost per patient episode was lower for patients in the remote monitoring group
than the comparison group (Dansky et al., 2001).

The Donabedian Quality Model

By using the Donabedian SPC framework to evaluate remote monitoring, this study
considered the critical components of the remote monitoring intervention program.
Consideration was given to influence of structure on process, process on outcomes, and the
interaction of structure and process on outcomes. A conceptual framework for the Donabedian
Quality Model is presented in Figure 2.0.
Structure and Process

The structure of home health care was modified by the addition of remote monitoring. In the context of home health care, social environment and living arrangements were considered alongside the HF diagnosis. Applying Donabedian’s Quality SPO Model, remote monitoring was conceptualized as the structural component that was influential on the outcomes of care. Therefore, the intent to treat or the degree to which patients used the remote monitoring system suggested the degree to which remote monitoring was implemented. Donabedian suggested that structure influenced the process of providing care (Nuckols, Escarce, & Asch, 2013). The structural component of the intervention program provided information that enabled the monitoring clinicians to positively recognize signs and symptoms of heart failure, if they existed. The recognition of a deteriorating condition initiated the process of care via telephone support. Through daily clinical monitoring and feedback, remote monitoring was postulated to decrease the number of home care visits. At the same time, the ability to proactively identify signs and symptoms of heart failure allowed the monitoring clinician to problem solve, via a root cause analysis. Ideally, this should decrease the number of skilled nursing visits and alleviate a
Assumptions
Information is required to improve decision making. Clinicians working in tandem with patients can improve care in the community.

External Factors
Other co morbidities may influence heart failure

Figure 2 The Conceptual Framework for the Donabedian Quality Model
potential physiological decline. The complexity of the process increased when the telephone support was not effective and face-to-face visits were required. The adequate structural support allowed problem-solving at lower levels of care, decreasing the costs (or complexity) of the clinical process. Figure 3 is a diagrammatic representation of the ideal structure – process relationship postulated by remote monitoring.

H1: When structural factors are held constant, better care structure leads to better clinical process.

H1a: There is a statistically significant difference in skilled nursing utilization between the standard of care and remote monitoring care groups in patients with HF.

H1b: There is a statistically significant difference in Net HHRG (net income) between the standard of care and remote monitoring care groups in patients with HF.

H1c: There is a statistically significant difference in agency costs between the standard of care and remote monitoring care groups in patients with HF.

Figure 3. Diagram of the Influence of Structure on Process of Heart Failure
Process and Outcomes

When the ideal process of care was not resolved via telephone support, the next level of care must be provided: home care visits by skilled nursing staff. The clinical assessment was supported by face-to-face visits (comprehensive clinical assessment) and electronically received health data on physiological status. These activities are critical to the decision-making process, which propelled the care plan. As a result, clinicians engaged in several decision-making options designed to mitigate hospital utilization if symptoms were not resolved with telephone support. The process of providing care was also conceptualized as the decision-making and collaboration that resulted from the additional information received from remote monitoring. This involved decision-making by home care nurses who were notified of an unresolved event and provided face-to-face assessments. From Figure 4, one sees that as the event was unresolved, higher levels of care were required, utilizing more resources. The following decision-making options were available: educating patients/caregivers, clinical interventions, notifying the physician, and hospital recommendations. When decision-making favored less utilization of resources at lower levels of clinical care, outputs were at acceptable levels. This resulted in favorable outcomes, including improved health status at the patient level, and increased economic efficiency at the agency (and potentially the system) level. One can deduce that when collaborative care was enacted in clinically adverse events, then clinical and economic outcomes were favorable. Based on this, the following was hypothesized:

H2: When structural factors are held constant, better care process leads to better clinical outcomes.

H2a: There is a positive relationship between clinician recommendations/decision-making and rate of hospital readmissions in patients with HF.
H₂₅: There is a positive relationship between clinician recommendations/decision-making and rate of emergency department visits in patients with HF.
Figure 4. Diagram of Process of Care Relationship to Outcomes for Visiting Nurses
Interaction of Structure and Process on Outcomes

The infrastructure offered by remote monitoring was supported for its ability to support clinical care by providing information to clinicians. However, the additional information has little value if not applied in the care process. In this way, structure may have an indirect causal link on outcomes, requiring an examining of the structure and process as interdependent components to affect change in outcomes. Therefore, one can postulate that the interaction between remote monitoring and process may have an influence on health care and cost outcomes (see Figure 5).

H3: The structure positively affects the process of care that will lead to better care outcomes.

H3a: Remote monitoring positively affects the process in home health care that will lead to statistically significant differences in health outcomes for patients with HF.

H3b: Remote monitoring positively affects the process will lead to statistically significant differences in cost outcomes for patients with HF.

Structure   Process   Outcomes

Figure 5. Diagrammatic Representation of the Interaction of Structure and Process on Outcomes

Literature Gap

The cumulative body of literature as cited in this chapter is inconclusive. Although several studies indicated the positive effects of remote monitoring, the high attrition rate of
participants led to a decrease in the effect size (Tompkins & Orwat, 2010). A systematic review of the literature by Clark et al. (2007) suggested that the results of telephone support and remote monitoring in patients with HF were also inconclusive. Although a similar study found that remote monitoring reduced mortality and increased quality of life, more studies are needed to affirm such results (Polisena et al., 2010). Appendix C provides a summary of remote monitoring’s effect on health care quality.

Several studies with positive outcomes suggested that larger sample sizes and an enhanced methodology were required for valid and reliable findings (Finklestein et al., 2006; Noel et al., 2004; Tompkins & Orwat, 2010). Polisena et al.’s (2010) review of the literature revealed that patients known to be in the remote monitoring program received more clinical care than the control group. The Hawthorne Effect and resultant bias were potentially problematic in many studies (Polisena et al., 2010; Takahashi et al., 2010). A study that included ten home health care agencies and examined patients with HF concluded that significant differences between hospital readmissions and ED visits occurred more frequently in the remote monitoring group than in the control group at 60 days after start of care, but not at 120 days (Dansky et al., 2008). However, the small sample size led to a lack of effect size. Desai (2012) posited that home remote monitoring is not sufficient to affect change in health care quality. He stated that the critical components of chronic disease management, patient involvement, timely interdisciplinary communication, and the ability of non-clinical personnel to administer care per physicians’ instructions were absent (Desai, 2012).

Preliminary studies claim that remote monitoring “works and has a positive clinical effect and increases the efficiencies in health services and technical usability” (Ekeland, Bowes, &
Flottorp, 2010, p. 739). Studies that were less confident about the efficaciousness of remote monitoring in randomized experimental studies remained hopeful about its potential benefits and recommended further research to solidify results (Ekeland et al., 2010).

Current research offers little economic support for remote monitoring; however, studies that offer support are often small in scale and are not held to the rigors of empirical research (McLaren & Ball, 1995). A systematic review by Whitten et al. (2002) found a paucity of studies that produced “robust and generalizable conclusions” (p. 1437). In light of these findings, academicians and researchers should strive for more well designed and implemented studies. More rigorous studies are needed to determine the cost effectiveness of remote monitoring and its long-term effectiveness and viability (Stuti et al., 2009). To justify its high costs, the use of technology should be measured against the current standards of practice. Research is needed to determine the effectiveness and efficiencies of such use.

**Chapter Summary**

Remote monitoring intervention programs use information and communication technologies to provide a clinical support structure to improve cost and quality (Li, Wang, Lu, Lin, & Yen, 2012). They are able to overcome geographical barriers between health care professionals and patients (Anker et al., 2011). Telemedicine technology provides more than a method to collect and store health information: it is an intervention strategy to mitigate financial and medical adverse events associated with HF. Remote monitoring is speculated to increase patient-provider communication and to enhance the availability of valid information that can be
used to make efficacious medical decisions. Such decisions can be used to enact early interventions before more serious, costly medical attention is needed.

By using Donabedian’s SPO quality model, this study proposed to examine remote monitoring as an intervention program to mitigate the adverse effects of heart failure. Through the analysis of the program, hospital utilization and economic effects were investigated.
CHAPTER THREE: METHODOLOGY

This study used a retrospective post test only, case matched design. Not only did this study add to the body of literature pertaining to the effectiveness of remote monitoring, but it also included a cost outcomes ratio analysis.

Study Instrument

Data were collected from the OASIS-C (Outcome and Assessment Information Set), via electronic medical record review. The OASIS-C is the latest version of the OASIS data set to be used by all Medicare-eligible recipients of home care services on or after January 1, 2010. The OASIS is the official data collection tool used by the Centers for Medicare and Medicaid Services (CMS) for all home health care agencies. The OASIS is required for admission into home health care and is completed every 60 days (one certification period), and for the following events: Transfer to Inpatient Facility, Death, and Agency Discharge. Continuing beyond 60 days requires Recertification of Care OASIS, in which the provider reassesses patients’ clinical and functional status to ascertain the need for continued services for another 60 day period. Medicare requires completion of OASIS data set as a means to collect following patient information: socio-demographics, environmental factors, support systems, health status, and functional status. These data provide a clinical assessment of the patients’ current medical status and evidence of the need for skilled nursing care. The OASIS provides a standardized method to plan care, measure quality, and determine reimbursement (O’Connor & Davitt, 2012).

The collected data are electronically submitted to CMS. OASIS data was collected by a qualified home care clinician (registered nurse or licensed physical therapist) through direct
observation and an interview of the patient and/or caregiver. Due to the nature of this study, OASIS data collection were completed by registered nurses, employed by the home health care agency. Questions used in this study from the OASIS are discussed and displayed in Appendix G.

**Study Variables**

Scientific inquiry was used to guide the study and to determine causality, confirm, describe, predict, or explain the relationship between two variables: remote monitoring and quality. The exogenous variable was remote monitoring, and was examined in relation to its influence on the endogenous variables: health care quality and health care cost. Health care quality refers to hospital utilization [heart failure-related hospital readmission (HF TIF) and total emergency department visits (TOTALER)] and clinical status (dyspnea). Health care cost refers to agency cost, the number of skilled nursing visits, and net HHRG (net income).

**Unit of Analysis.** Unit of the analysis is the patient. Event history was explored to ensure that unique patients were examined in the study; such that patients with multiple entries into home care are counted one time. The first home care episode (in the study period) was examined.

**Remote monitoring.** The intensity of telemonitoring was collected by the primary investigator. The Phillips Company (manufacturer of the remote monitoring system) collected and stored data on patient utilization of remote monitoring. Remote monitoring was used daily (7 days a week) in the morning. Data are available on the number of missed/actual remote monitorings. Patients were asked to use their installed monitoring system one hour after their
prescribed morning medications. Data were sent to a central station maintained by Phillips, where a monitoring clinician was able to assess patient status.

**Diagnosis.** The literature suggested that comorbidities are a significant contributor to likelihood of hospital utilization and mortality events (Manning, 2011; Muzzarelli et al., 2010). Therefore, study participants were included in the study based on primary and secondary diagnosis of HF (ICD-9, categories of 428.00). Diagnosis was quantified in severity as denoted in OASIS Question M1020.

**Functional Acuity.** Functional acuity is strongly correlated to morbidity as a significant predictor of hospitalization (Courtney et al., 2012; Manning, 2011). The maintenance of functional mobility was postulated to be an important aspect of independent aging, thereby reducing health care costs and institutionalization (Webber, Porter, & Menec, 2010). Functional acuity was assessed by the clinician at OASIS Start of Care.

**Clinical Acuity.** The clinical status of study participants after inpatient hospitalization may vary. Clinical questions were extracted from the cardiopulmonary portion of the OASIS and included in the study. Appendix G highlights relevant questions pertaining to clinical status. This included M1034, which assessed the overall clinical status and hospitalization risk. M1400 was a measure of patient dyspnea and shortness of breath, commonly associated with heart failure. M1500 measured symptoms directly related to heart failure and M1510 was included as a process measure of care.

**Cognitive/behavioral status.** Changes in cognition are recognized as predictors of hospital readmission and therefore included in the analysis. A decrease in cognitive status may lead to hospital utilization. These questions are reflected in M1700 and M1730.
Race. The literature suggested that race/ethnicity was a significant contributor to hospital readmissions (Lee et al., 2009; Muzzarelli et al., 2010). Muzzarelli et al. (2010) study indicated that African Americans experienced significantly more hospitalizations than Hispanics, followed by Whites. An exploratory study found that while African Americans did not suffer from higher mortalities than non-African Americans, African Americans had poorer health outcomes (Clarke, Davis, & Nailon, 2007).

Age. Hussain and Rivers (2009) suggested that health care utilization increases as one ages; this contributes to the significant increase in cost associated with age. Sylvia et al. (2008) also suggested that chronic diseases and comorbidities increase concurrently with age.

Gender. The literature was inconclusive about gender as a predictor of health quality. While some studies demonstrated that hospital admissions were higher for males than females, others suggested that gender was not a significant independent predictor of hospital utilizations in patients with HF (Lee, Capra, Jensvold, Gurwitz, & Go, 2004; Robertson et al., 2012). This factor was recorded in this study for descriptive purposes and case matching.

Socioeconomic status. Zip code was used for case matching for socioeconomic status. Data was retrieved from the 2010 census bureau to examine median income and educational level in a given zip code.

Hospital Readmissions. Heart failure-related hospital readmissions are considered in this study. Hospital readmissions may be direct readmissions or admissions through emergency departments. Emergency care, with or without hospital readmission, was denoted by OASIS Question M2300, M2310, and M2430
Emergency Department Visits. Emergency department visit refers to emergency care without hospital readmission. Emergency care with or without hospital readmission was denoted by OASIS Question M2300, M2310, and M2430.

Social Support. Social support was conceptualized as type of help received (Wan & Weissert, 1981). M2110 Question from the data set reflected the received amount of care needed by the patient. It assessed the caregiver’s ability and willingness to provide assistance, if needed. Appendix G displays M2110.

Social Environment. Living arrangement assessed the participant’s living situation and how frequently caregivers are in the home and are available to provide assistance. Appendix G displays question M1100.

The home care discharge date was included for all participants for examination of the period of time (days) services were rendered. This indicator was used to determine the beginning and ending of a home care episode or 120 days, whichever comes first. The remote monitoring discharge date was documented for length of time on remote monitoring. Included in this end point was the number of remote monitoring days that were ordered and how many were actually completed. This allowed analysis of compliance with remote monitoring program and prevents self-selection of “compliant” participants that may favorably skew results. This was used in analysis of participants who completed the remote monitoring program and comparative analysis of the entire group of those who had “intent” but did not complete it.
**Sampling**

Data were gathered from a home health care agency that used remote monitoring. The sample consisted of all patients who received home health services through the agency and experienced a recent hospital discharge. The enrollment period included hospital inpatient discharges from January 1, 2010 to hospital inpatient discharges May 31, 2013. To observe patient outcomes, the study period was January 1, 2010 to September 30, 2013. Individuals meeting inclusion criteria were included in the study. Individuals meeting the inclusion criteria and did not participate in the remote monitoring program were in the comparison/control group. Due to possible selection bias of successful participants on remote monitoring, all patients meeting inclusion criteria were selected until suggested sample size was attained, beginning with January 1, 2010 admissions until May 31, 2013 with study period until September 30, 2013 (end of enrollment period plus two potential certification periods or 120 days). One researcher gathered all data. All patients who did not receive remote monitoring and met inclusion criteria were included for the study.

Inclusion criteria are as follows:

1. Male or female who are Medicare eligible
2. HF, as primary or secondary diagnosis, and
3. Under current MD care, and
4. Recent discharge from a long term or acute care hospital.

Exclusion criteria include the presence of any of the following:
1. Decreased cognition with combative or aggressive character traits such that with a caregiver, the subject cannot reasonably be expected to complete the intervention, as determined by a physician and family input, or

2. No telephone access by subject or caregiver, or

3. Functional limitations that inhibit use of remote monitoring system

By definition, power is the ability to find a statistically significant difference when the null hypothesis is in fact false. In other words, the study seeks to find a difference when a real difference occurs. The sample size, the alpha level, and the effect size determine the study of power. The sample size is the number of units available in the study. Effect size refers to the strength of the relationship or the salience of the treatment compared to the noise in measurement. The alpha level (set at 0.05) refers to the odds that the observed result is due to chance. The lower the alpha, the more rigorous the test and the less likely it is that you will make a type I errors (rejecting the null when it is true). However, by decreasing the chances of type I errors, one increases the chance of type II errors (failing to reject the null when it is false). Power analysis was used to estimate sample size. An adequate sample size will increase the likelihood that the test will be able to detect a difference, if one exists. A sample size that is too small will lack the precision to produce reliable answers for the investigation. A sample size that is too large will use unnecessary time and resources for limited gain. The sample size for the anticipated effect size of 0.10, statistical power level of 0.80, and probability level of 0.05 requires minimum sample size of 200, allowing for missing cases and incomplete data. Using Cohen’s d and parameter estimation of 10 to 20 participants per parameter, 200 is adequate to detect the size of the effect, if one exists.
Clinical Procedures

As a retrospective chart review, data were collected during the treatment programs. Participants in this study used a remote monitoring system provided and installed by the agency. The standard system provided all participants with a blood pressure cuff, an electronic scale, and pulse oximetry all interconnected and placed in the patient’s home. The system was linked to a central station that was maintained by Phillips. See Figure 6.

**Figure 6 Diagrammatic Summary of Remote Monitoring Procedures.**

Each monitoring triggered a process of care: data collection, transmission, evaluation, notification, and intervention (if needed). Each subject was monitored daily. Three baseline physiological data were collected at the commencement of the program for participants in the
intervention group. This baseline was used during the follow-up monitoring to assess significant physiological variations. Every morning subjects used the installed remote monitoring system that assessed physiological status. Remote monitoring systems also asked a series of questions in regards to heart failure, diet, and symptoms, as shown in Table 2. Collected data were transmitted to the central agency and evaluated. Notification was sent to the respective home care agency site (see Figure 7) if abnormalities were not resolved via telephone support. The agency recorded and alerted clinical staff for abnormal readings. Abnormal readings included the following factors: weight that varies by more than five pounds, blood pressure readings that vary by more than ten points on systolic/diastolic, heart rate above 120 and below 60, and SO2 saturation below 94 percent. If no reasonable explanations were given for the abnormality, the visiting nurse contacted the appropriate physician for further orders. Subjects may have been ordered to the hospital where necessary medical assessments were performed. Upon being discharged to return home, remote monitoring system resumed. If hospital admission was not ordered, physician recommendations were followed and home care resumed. Subjects resumed remote monitoring every morning. During the study, the clinical data for comparison subjects were emergency department visits and hospitalizations. Guidelines for clinical practice specific to heart failure were used to guide clinical practice. Guidelines were followed for all patients diagnosed with heart failure. If remote monitoring was used, then the technology was included in the plan of care.
Table 2 Questions from Remote Monitoring Program

1. Are you experiencing more difficulty breathing today compared to a normal day?
2. Have your ankles been swollen more than usual?
3. Have you developed a cough?
4. Are you more tired compared to a normal day?
5. Are you having difficulty following your diet?
6. Are you having any dizziness?
7. Has your doctor added, deleted, or changed any of your medications this week?
8. Have you been having any chest pain?
9. Are you having any headaches?
10. Have you used your nitroglycerin in the last day?
11. Have you had any blurred vision today?

Figure 7 Summary of Information Processing for Remote Monitoring.
Data Collection and Handling

This quantitative research used posttest only control case matched design. Those meeting the inclusion criteria and who participated in the remote monitoring program were assigned to the intervention group. Those meeting the inclusion criteria and who did not participate in the remote monitoring program were in the control group. Retrospective chart reviews were performed through the review of electronic medical records. IRB was obtained September 2013.

Statistical Analysis Plan

Primary Objective: Quality outcomes. Descriptive statistics (frequency, means, and standard deviations) were calculated for all demographic and baseline levels of all clinical outcome variables or endpoints. This calculation provided for the general description of the study sample. Inferential statistics were used to draw conclusions about the study group and to make generalizations about a larger class of subjects based on the limited sample of subjects (Wan, 2002). The data analysis included ANOVA, path analysis, structural equation modeling (SEM), Automatic Interaction Detector Analysis (AID), and an independent t-test.

Secondary Objective: Cost Outcomes Ratio. Descriptive statistics (frequency, means, and standard deviations) were calculated for all related costs. Cost Outcomes Ratio was used to analyze the cost per outcome. An independent t test was employed to determine the statistical significance of the results.
**Propensity Score Matching and Analysis**

Random assignment is supported for its statistical advantages to ensure that group characteristics are relatively equal and differed only in assigned group (Heinrich, Maffioli, & Vazquez, 2010). However, random assignment is not always feasible in clinical practice. Some interventions must be developed and implemented prior to study commencement and cooperation may be costly to obtain (Heinrich et al., 2010). Therefore, non-experimental evaluation methods are supported to facilitate the understanding of the effectiveness of interventions despite assignment limitations (Heinrich et al., 2010). Propensity score is a conditional probability that expresses how likely a participant is to be assigned to a treatment or control group (Heinrich et al., 2010; Luellen, Shadish, & Clark, 2005; Thoemmes & Kim, 2011). The goal in propensity scoring is to create a balance in the observed covariates and recreate a situation that would be expected in a randomized experiment. To avoid selection bias, “matching methods find a non-treated unit that is similar to a participating unit, allowing for an estimate of the intervention’s impact as the difference between a participant and the matched comparison case” (Heinrich et al., 2010, p. 4). Similar to all probabilities, propensity scores range from 0 to 1 (Luellen et al., 2005). In a truly randomized assignment, each person has an equal chance of being selected in either group (Luellen et al., 2005). In this study, the true propensity score was unknown. Therefore, propensity score was used to balance non-equivalent groups using matching and weighting on the propensity score (Luellen et al., 2005).

Statistical software R-program was used for the propensity score matching (PSM) and analysis. In this study, there are potentially more participants who received remote monitoring than those who did not. For technical reasons, a larger control group was selected than the group
receiving the remote monitoring intervention. Treatment participants were matched based on primary and secondary diagnosis, and clinical acuity components of the OASIS data set (as related to cardiopulmonary assessments): race, age, socioeconomic status, and gender to a control participant.

The nearest neighbor matching approach was used to match the comparison with the intervention group (Austin, 2010). Austin (2010) suggested that nearest neighbor matching method optimizes the “estimation of treatment effects” (p. 1095). Propensity scores were computed by modeling a logistic regression with the dependent variable as the probability of receiving the remote monitoring intervention and the independent variables of age, gender, race, zip code, and clinical acuity (Sun et al., 2012). A single propensity score was estimated for every individual in the study and was used to adjust for the difference between the two groups (Reeve, Smith, Arora, & Hays, 2008). The intervention participants were matched using the generated propensity score with a participant from the comparison group. Once matched, the pair was removed from the list of intervention and comparison group and added to the study (Rosenbaum & Rubin, 1985).

Propensity matching is met with limitations. A strong internal validity was not guaranteed, as it assumes that all variables related to both outcomes and treatments assignments are included in the observed covariates (Luellen et al., 2005). The degree of reduction bias achieved was influenced by the efficiency of the estimators, sample size, and the sources of the nonequivalent groups (Luellen et al., 2005).
Data Analysis

Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 18.0. Descriptive statistics were used to describe the study sample: means, standard deviation, frequency, and percent, as applicable to categorical and continuous variables.

ANOVA. Inferential statistical analysis was conducted using the analysis of variance (ANOVA). Separate, one way ANOVA procedures were used to test the significance between groups (levels of intensity of remote monitoring) for hospital readmissions and emergency department visits. Tests of normality and homogeneity were conducted to test the assumptions for the ANOVA procedures.

Split plot ANOVA. A split plot ANOVA design was used to investigate the impact of the intensity of remote monitoring on clinical status. Tests of equality of variance and equality of covariance were conducted via Levene’s test and Boxes’ test, respectively.

Path Analysis. It is suggested that the maturity of a scientific discipline is measured by the complexity and specificity of the questions (Hoyle, 1994). As statistical methods advance, it is critical that investigators harness and employ appropriate methodologies to address the complexities of the health care system (Hoyle, 1994). The scarcity of resources available to many organizations, compared to the large amount of resources required, stipulates that an intervention be effective across many indicators. Path analysis is a methodology in which one can visually see the relationships among variables. It assisted in determining to what degree, if any, can the observed data be explained in terms of the smaller number of factors or predictor variables (Helitzer et al., 2010). Operationalizations of study variables are noted in Appendix E.
Structural Equation Modeling (SEM) addresses the “mandate for more flexible and sophisticated approaches to clinical research questions” (Hoyle, 1994, p. 428). SEM is appropriate in this analysis due to the consideration of constructs and multiple indicators. The two step process includes the measurement model and the SEM. The measurement model provides a representation of how the latent variable is measured in terms of the observed variables. SEM was used to determine the relationship between the latent exogenous variables, structure and process, and the latent exogenous variables, cost and quality. Latent exogenous variable of structure considered the intent to treat of remote monitoring, social support, and social environment. Latent exogenous variable of process refers to the decision-making options represented by M1510. Cost will be observed by agency cost, net HHRG, total skilled nursing visits. Health will be observed by dyspnea status at discharge, hospital readmissions, and emergency department visits. Operationalization of study variables for this model is presented in Appendix L.

**Donabedian Process Analysis: Dtreg**

Patient information at the point of care enhances collaboration such that practitioners, given a set of predictor variables, are able to affect favorable change in quality outcomes. This analysis answered the question: by having patient information at the point of care, what is the relationship between clinical decision-making and hospital utilization? This analysis was based on an Automatic Interaction Detector Analysis, using Dtreg to strategically detect meaningful relationships between a set of predictor variables and a dependent variable. Dtreg can be used to
reveal the relationships among predictor variables that are potentially invaluable to clinicians’ efforts to decrease hospital utilizations.

The first step was to identify predictor variables for hospital utilizations. The literature posits that patient characteristics of age, sex, race, socio-economic status, co-morbidities (as reflected in primary and secondary diagnosis), clinical acuity, and functional acuity are predictors of hospital utilization (Priebe et al., 2011). The literature also suggested that social support and social environment are perceived as mediating factors, which support patients with chronic illness (Wan & Weissert, 1981). The second step involved a descriptive analysis performed by SPSS (version 18). During the third step, a correlation matrix was performed by SPSS to detect whether there are strong correlations between predictor variables. If a strong correlation was found at the 0.7 level, then correlated variables were adjusted. Fourthly, AID analysis was performed to detect the interactions among predictor variables.

The AID analysis has some limitations. The minimum size for each group can affect the statistical stability. This study used an adequate sample size to minimize this limitation. Because temporal factors are not specified, causal inferences cannot be made. However, it may help in revealing the potential direction of causal sequence. Logical interpretations of the model must be tested with observable evidence and replicated with different samples (Wan, 2002).

**Cost Outcomes Ratio**

A systematic evaluation of remote monitoring requires consideration of the patient, provider, and overall impact on the health care system (Ruckdäschel, Reiher, Rohrbacher, & Nagel, 2006). While considering the medical potentials of remote monitoring to improve public
health, the attenuating resources of the health care system require decision makers to take a prudent approach to achieve stated goals. Applying economic principles, one asks: Can remote monitoring provide at least the same level of care (or better) with fewer resources? (Ruckdäschel et al., 2006). An economic evaluation was required to determine if the cost saving is justified by the degree of achievement (Ruckdäschel et al., 2006). Therefore, remote monitoring should be compared to current standards of care to determine if this provides a cost efficient alternative.

\[ \text{Cost-Outcome Ratio} = \frac{\text{Total Cost}}{\text{Units of Effectiveness}} \]

1) Hospital Admission = \( \frac{\text{Total Cost}}{\text{Hospital Readmission}} \)
2) Emergency Department Visits = \( \frac{\text{Total Cost}}{\text{Emergency Department Visit}} \)

The cost analysis examined the cost per outcome as compared to the usual care. In light of the current literature, remote monitoring was evaluated on its ability to improve health care quality outcomes, and thus, reduce the cost of health care. Cost studies have significant implications in helping health care professionals promote evidenced-based care in the most cost efficient methodology.

The costs of the remote monitoring system included: capital costs of remote monitoring units, additional employees required to operate the remote monitoring program, and the difference in nursing utilization. The cost of providing care, including the number of nursing visits and net HHRG, in one home care episode was obtained from chart reviews. Administrative and equipment costs were provided by the agency via a profit and loss statement for fiscal year 2012 and January to September 2013. An episode was defined as one admission to discharge period per patient. Based on the literature review, the assessment of provider level costs was as follows:
1) Total TM Cost = (TM Capital Cost –/+ nursing utilization)/observed quality measure.

2) Total Standard of Practice Cost = (Total Cost of Standard Practice -/+ nursing utilization)/observed quality measure.

where nursing utilization is the average number of nursing visits in per episode.

Cost effectiveness decisions are guided by several options:

(1) If the two interventions of care being considered are equal in outcomes, then one considers the least costly option.

(2) If both methods of care are equal in cost, then one considers the most effective intervention program.

(3) However, if the most costly method produces the better outcomes, then one must consider incremental cost effectiveness.

**Hypothesis Testing**

Cost Outcomes Ratio. H1 was tested using independent t test. This was an appropriate test to use as this study compares the means of two different groups. Process of care measures on health outcomes was analyzed using AID: Dreg.

The ANOVA, SEM, and path analysis are used to explain the proposed hypotheses (H3). The path coefficient estimates the causal linkages between the exogenous and endogenous variables. Path analysis provided a graphical representation of an assumed relationship between the variables (Wan, 2002). The path coefficient (standardized regression coefficient) was interpreted as the net change in the endogenous variable that was affected by one standard deviation change in the exogenous variable (Wan, 2002). Data were analyzed using SPSS Amos
18. Model criteria included the examination of the solution, measure of overall fit, and detailed assessment of fit. An examination of the solution determined if the parameters are the right sign and size, if squared multiple correlations were reasonable, and if measurement errors were reasonable. Overall fit uses chi-square ratio, and RMSEA <0.05, CFI > 0.9, GFI > 0.9, and AGFI > 0.9. The goodness of fit index measured the degree to which the amount of variance and covariance can be accounted for by the model. The AGFI is the GFI, but it also accounted for degrees of freedom. The root means square area of approximation measured the discrepancy in fit per degrees of freedom. P-value > 0.05 allowed the inquirer to accept the null that the model fits the data. Detailed assessment of the fit using modification indices was used to determine the lack of model fit. Poor model fit was improved by eliminating parameters that are not statistically significant. (Wan, 2002)

As an extension of regression, SEM provided a graphical presentation of the relationship between the study’s variables (Wan, 2002). The structural model corresponded to the models interested in the relationship among the exogenous and endogenous variables (Hoyle & Smith, 1994). By using a confirmatory approach, the proposed structural model was based on a theoretically informed framework (Hox & Bechger).

**Chapter Summary**

This study used scientific inquiry via a retrospective post test only, case matched design. Not only will this study add to the body of literature for the efficaciousness of remote monitoring to promote quality, but it also added a Cost Outcomes Ratio that provided a comparative analysis against traditional models of health care delivery. The unit of analysis was the patient, with a
diagnosis of HF, who had recently discharged from long term or acute care hospital, and admitted to a home health care agency. Study variables were collected from the OASIS C data set.

The agency of interest was a national home care agency, 70 of its offices provided the remote monitoring services. Due to possible selection bias of successful participants on remote monitoring, all patients meeting inclusion criteria were selected until the suggested sample size was attained, beginning with January 1, 2010 admissions, until May 31, 2013 with study period, and until September 30, 2013 (end of enrollment plus two potential certification periods or 120 days).

Clinical Outcomes. This study used propensity score matching, via nearest neighbor matching to create relatively equal groups based on specified variables. Analysis of variance was used to test the hypothesis and path analysis was used for pictorial representation of the relationship between the variables and the outcomes of interest, hospital readmissions, and emergency room visits. Split plot ANOVA was used to examine the effect on remote monitoring on clinical outcomes. Remote monitoring provided a digital infrastructure to the home health care program, therefore Dtreg was used to investigate the process outcomes of participants with heart failure symptoms, i.e. how the clinical decision-making process affects hospital utilization.

Cost Ratio Outcomes. Cost was assessed via an independent t test and Cost Outcomes Ratio to determine, based on the specified decision-making rule, the program that warrants the most consideration. Cost was analyzed from the agency perspective.
CHAPTER FOUR: RESULTS

Propensity Score Matching and Analysis

Propensity score matching was performed to promote a relative balance in the observed covariates. The analysis was performed using R-Project.Org with the subroutine of Matchit. Matching was performed using the following covariates: age, gender, median income, median educational level, and clinical acuity. Three hundred twelve potential participants entered the propensity score analysis (207 control and 105 treated), 105 were matched and 102 were unmatched. Logistic regression generated the propensity score for each patient. R

![Distribution of Propensity Scores](image)

Figure 8 Results of Match Covariates after Propensity Score Analysis

Descriptive Statistics

Descriptive statistics are provided using SPSS version 18.0. The total sample size was 210 (105 in usual care and 105 in the intervention group). The sample consisted of participants
from 23 offices across the continental United States from one parent organization. The average age was 77.7 years and 76.7 years, usual care and intervention group respectively. Table 3.0 displays the results for both groups. The descriptive analysis shows that Total ER visits reflected four percent of the total sample, well below the national average of 12 percent for home health care agencies. Data suggest no ER visits were due to heart failure symptoms. Total HA was 34.8 percent of total sample, which was significantly above the 17 percent national average. Hospital readmission rate due to heart failure reflects 24.6 percent of the total readmissions. See Appendix I Table 1 and Figure 1 and Table 2 for a summary of reasons for Total HA and ER.

**Table 3 Descriptive Statistics for Usual Care and Remote Monitoring Groups**

<table>
<thead>
<tr>
<th>Description</th>
<th>Usual Care (n = 105)</th>
<th></th>
<th>Intervention (n = 105)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>49</td>
<td>46.7</td>
<td>46</td>
<td>43.8</td>
</tr>
<tr>
<td>Female</td>
<td>56</td>
<td>53.3</td>
<td>59</td>
<td>56.2</td>
</tr>
<tr>
<td>White</td>
<td>49</td>
<td>82.9</td>
<td>46</td>
<td>81.9</td>
</tr>
<tr>
<td>Black</td>
<td>13</td>
<td>12.4</td>
<td>12</td>
<td>11.4</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4</td>
<td>3.8</td>
<td>6</td>
<td>5.7</td>
</tr>
<tr>
<td>Asian</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total ER</td>
<td>3</td>
<td>2.85</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>Total RA</td>
<td>35</td>
<td>16.7</td>
<td>38</td>
<td>18.1</td>
</tr>
</tbody>
</table>

**Analysis of Variance**

One way ANOVA was used to examine the differences, if any, in hospital readmissions due to heart failure. The independent variable: intent to treat (ITT) was presented in five levels of treatment compliance: 0 = 0 percent completion of any remote monitoring, 1 = .001 to .25
completion of remote monitoring, 2 = .26 to .50 of remote monitoring completion, 3 = .51 to .75 completion of remote monitoring; and 4 = 0.76 to 1.00 completion of remote monitoring as ordered by prescribed physician. However due to small sample size in group 1, group 1 (n = 2, mean = 0.00), group 2 (n = 8), and 0 (n = 118) were combined to group 0 (n = 128); based on similarity of HF TIF mean (Heart failure-related hospital readmissions). Results of HF TIF are reflected in Table 4.
Table 4 Summary of Descriptive Statistics for Heart Failure-related Hospital Readmissions

<table>
<thead>
<tr>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>128</td>
<td>0.14</td>
<td>0.349</td>
<td>0.08</td>
<td>0.2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>0.47</td>
<td>0.516</td>
<td>0.18</td>
<td>0.75</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>0.09</td>
<td>0.288</td>
<td>0.02</td>
<td>0.16</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>0.15</td>
<td>0.356</td>
<td>0.1</td>
<td>0.2</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
ANOVA testing assumed that the data in each group are random samples from the same population, samples are independent, and observations within the group are independent. The Levene’s Test displayed a probability coefficient of 0.000. Since this value is less than 0.05, the null hypothesis of equal variance is rejected and a difference between the variances in the sample was considered. The assumption of homogeneity of variance was not supported. Normal distribution was not supported. However, the F test is robust.

**Table 5 Summary of ANOVA Results of Heart Failure-related Hospital Readmissions**

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1.759</td>
<td>2</td>
<td>0.88</td>
<td>7.381</td>
<td>0.001</td>
</tr>
<tr>
<td>Within Groups</td>
<td>24.665</td>
<td>207</td>
<td>0.119</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26.424</td>
<td>209</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Heart Failure Hospital Readmissions.** There was a statistically significant difference at the p<0.05 level; F (4, 207) = 7.381, p = 0.001. Therefore, we reject the null and consider that the use of remote monitoring in home health care will lead to statistically significant difference in hospital readmissions in patients with HF. A Post Hoc comparison using Tamhanes test indicated that the mean score for group 3 was statistically significantly different from group 0 (M = 0.14, SD = 0.349) and group 4 (M = 0.09, SD = .288).

**Emergency Department Visits.** There was no statistically significant difference at the p < 0.05 level for hospital utilization as defined as emergency department visits. F (4, 205) = .211, p = 0.932. Therefore, we fail to reject the null and consider that there is no statistically significant
decrease in emergency department visits. Analysis suggests that no emergency department visits without hospital admissions were due to heart failure symptoms.

**Path Analysis**

**Heart Failure Hospital Readmissions.** The path analysis was performed to show the strength of the relationship of the hypothesized association between variables. The path analysis was completed using Amos 18.0 software to estimate the path coefficients for the model. An initial model (see Figure 9) was developed using as the following predictors: intent to treat (ITT), age, race, gender, HF severity, COPD severity, dyspnea (M1400), M1034, M1100, M2110, Clinical acuity (CA) and functional acuity (FA) on the target variable HF TIF. Model fit summary indicated p value < 0.05 (N = 210, p value = 0.000; Chi squared = 132.987, 55 DF; x²/DF = 2.418; RMSEA = 0.082 CFI = 0.114; GFI = 0.883 and AGFI = 0.849). A revised model was generated using modification indices and correlation notes from the model. Model notes suggested a relationship between clinical acuity and M1034, M2110 and intent to treat, M1034 and intent to treat, and functional and clinical acuity. A revised model suggests, as indicated in Figure 10, that predictors accounted for 9% of the variance in HF TIF. Clinical and Functional Acuity were the most significant predictors of hospital readmissions. The model fit for this model was found to be acceptable at p value > 0.05 (N = 210, p value = .201; Chi squared = 14.608, 17 DF; x²/DF = 1.328; RMSEA = 0.040; CFI = 0.933; GFI = 0.980 and AGFI = 0.950).
Figure 9 Proposed Path Analysis on the Predictors of Hospital Readmission
Table 6 Goodness of Fit Statistics for Heart Failure-related Hospital Readmissions

<table>
<thead>
<tr>
<th>Fit Indices</th>
<th>Criterion</th>
<th>Original Model</th>
<th>Revised Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared</td>
<td>Low</td>
<td>132.987</td>
<td>14.608</td>
</tr>
<tr>
<td>Pvalue</td>
<td>$\geq 0.05$</td>
<td>0.00</td>
<td>0.201</td>
</tr>
<tr>
<td>DF</td>
<td>$\geq 0$</td>
<td>55</td>
<td>17</td>
</tr>
<tr>
<td>$\chi^2$/df</td>
<td>$\geq 0$</td>
<td>2.418</td>
<td>1.328</td>
</tr>
<tr>
<td>RMSEA</td>
<td>$\leq 0.04$</td>
<td>0.082</td>
<td>0.04</td>
</tr>
<tr>
<td>CFI</td>
<td>$\geq 0.90$</td>
<td>0.114</td>
<td>0.933</td>
</tr>
<tr>
<td>GFI</td>
<td>$\geq 0.90$</td>
<td>0.883</td>
<td>0.98</td>
</tr>
<tr>
<td>AGFI</td>
<td>$\geq 0.90$</td>
<td>0.849</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Table 7 Standardized Estimates of the Revised Path for Heart Failure-related Hospital Readmissions

<table>
<thead>
<tr>
<th></th>
<th>Standardized Estimates</th>
<th>Unstandardized Estimates</th>
<th>S.E.</th>
<th>C.R.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFTIF</td>
<td>COPD</td>
<td>-0.137</td>
<td>-0.042</td>
<td>0.02</td>
<td>-2.067</td>
</tr>
<tr>
<td>HFTIF</td>
<td>M1034</td>
<td>0.08</td>
<td>0.046</td>
<td>0.039</td>
<td>1.173</td>
</tr>
<tr>
<td>HFTIF</td>
<td>ITT</td>
<td>0.006</td>
<td>0.006</td>
<td>0.061</td>
<td>0.094</td>
</tr>
<tr>
<td>HFTIF</td>
<td>M1100</td>
<td>-0.135</td>
<td>-0.018</td>
<td>0.009</td>
<td>-2.05</td>
</tr>
<tr>
<td>HFTIF</td>
<td>M2110</td>
<td>-0.044</td>
<td>-0.002</td>
<td>0.003</td>
<td>-0.663</td>
</tr>
<tr>
<td>HFTIF</td>
<td>CA</td>
<td>0.136</td>
<td>0.005</td>
<td>1.895</td>
<td>0.058</td>
</tr>
<tr>
<td>HFTIF</td>
<td>FA</td>
<td>0.102</td>
<td>0.011</td>
<td>1.452</td>
<td>0.147</td>
</tr>
</tbody>
</table>
Figure 10 Revised Path Analysis of the Predictors of Hospital Readmission

Emergency Department Visits. The original hypothesized model depicted the arrangements of exogenous variables and their correlations with the endogenous variables, as shown in Figure 11. Chi-squared was 200.151, DF 105, p value = 0.000, x2/DF = 1.906; CFI = 0.079, GFI = 0.883, AGFI = 0.849, and RMSEA = 0.066. Based on the correlation matrix and modification indices on the original model, indicators that negatively affected the model were deleted. The model was revised with the remaining variables. The revised model suggested that the predictors accounted for 9% of the variance on TOTALER. Clinical Acuity and M1034 (Overall patient status) were found to be the greatest contributors to emergency department visits without hospital readmissions. The model fit for this model was found to be acceptable at p value
> 0.05 (N = 210, p value = 0.662; Chi squared = 4.985, 7 DF; x2/DF = .712; RMSEA = 0.000; GFI = 0.992, AGFI = 0.976, CFI = 1.000). See Figure 12.
Figure 11 Proposed Path Analysis on the Predictors of Emergency Department Visits
Table 8 Goodness of Fit Statistics for All Cause Emergency Department Visits

<table>
<thead>
<tr>
<th>Fit Indices</th>
<th>Criterion</th>
<th>Original Model</th>
<th>Revised Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared</td>
<td>Low</td>
<td>200.151</td>
<td>4.985</td>
</tr>
<tr>
<td>Pvalue</td>
<td>&gt; 0.05</td>
<td>0.00</td>
<td>0.662</td>
</tr>
<tr>
<td>DF</td>
<td>≥ 0</td>
<td>105.00</td>
<td>7.00</td>
</tr>
<tr>
<td>x2/df</td>
<td>≥ 0</td>
<td>1.906</td>
<td>0.712</td>
</tr>
<tr>
<td>RMSEA</td>
<td>≤ 0.04</td>
<td>0.066</td>
<td>0.00</td>
</tr>
<tr>
<td>CFI</td>
<td>≥ 0.90</td>
<td>0.079</td>
<td>1.00</td>
</tr>
<tr>
<td>GFI</td>
<td>≥ 0.90</td>
<td>0.883</td>
<td>0.992</td>
</tr>
<tr>
<td>AGFI</td>
<td>≥ 0.90</td>
<td>0.849</td>
<td>0.976</td>
</tr>
</tbody>
</table>

Figure 12 Revised Path Analysis of the Predictors of Emergency Department Visits
Table 9 Standardized Estimates from the Revised Model of All Cause Emergency Department Visits

<table>
<thead>
<tr>
<th></th>
<th>Standardized Estimates</th>
<th>Unstandardized Estimates</th>
<th>S.E.</th>
<th>C.R.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>TotalER &lt;---</td>
<td>Race</td>
<td>0.1</td>
<td>0.029</td>
<td>0.019</td>
<td>1.496</td>
</tr>
<tr>
<td>TotalER &lt;---</td>
<td>HF</td>
<td>0.083</td>
<td>0.02</td>
<td>0.017</td>
<td>1.224</td>
</tr>
<tr>
<td>TotalER &lt;---</td>
<td>M1034</td>
<td>0.128</td>
<td>0.032</td>
<td>0.018</td>
<td>1.828</td>
</tr>
<tr>
<td>TotalER &lt;---</td>
<td>ITT</td>
<td>-0.064</td>
<td>-0.026</td>
<td>0.027</td>
<td>-0.937</td>
</tr>
<tr>
<td>TotalER &lt;---</td>
<td>CA</td>
<td>0.138</td>
<td>0.004</td>
<td>0.002</td>
<td>1.999</td>
</tr>
</tbody>
</table>

The results also indicated that participants receiving remote monitoring and who completed 51 to 75 percent of the monitoring had higher hospital readmission rates. Therefore, further analysis was warranted. Descriptive statistics are provided in Table 10.

An Analysis of Variance considered potential differences in heart failure symptoms between groups. The Levene’s Test displayed a probability coefficient of 0.013. Since this value was less than 0.05, we reject the null hypothesis of equal variance and consider that there is a difference between the variances in the population. The assumption of homogeneity of variance was not supported. While mean heart failure symptoms increased for group 3, p value > 0.05 (p = 0.083), statistical significant is not supported. However, clinical significance may be noted due to the relative increase in heart failure symptoms for group 3 as compared to groups 0 and 4. See Table 11 and Figure 13.
Table 10 Summary of Results of Descriptives of HF Symptoms

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>95% Confidence Interval for Mean</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>128</td>
<td>0.24</td>
<td>0.43</td>
<td>0.038</td>
<td></td>
<td>0.17</td>
<td>0.32</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>0.47</td>
<td>0.516</td>
<td>0.133</td>
<td></td>
<td>0.18</td>
<td>0.75</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>0.19</td>
<td>0.398</td>
<td>0.049</td>
<td></td>
<td>0.1</td>
<td>0.29</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>0.24</td>
<td>0.43</td>
<td>0.03</td>
<td></td>
<td>0.18</td>
<td>0.3</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 11 Summary of ANOVA Results

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>0.911</td>
<td>2</td>
<td>0.456</td>
<td>2.501</td>
<td>0.084</td>
</tr>
<tr>
<td>Within Groups</td>
<td>37.703</td>
<td>207</td>
<td>0.182</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>38.614</td>
<td>209</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 13 Graph of Heart Failure Symptoms and Heart Failure Hospital Readmissions
A split plot ANOVA design was used to investigate the impact of remote monitoring (intent to treat as categorized above) on clinical status. Clinical status will be conceptualized as dyspnea (M1400), as a principle manifestation of heart failure as captured by the OASIS. The cases selected for analysis were those who had both the pre and post tests completed.

Dyspnea (M1400). A summary of descriptive statistics for dyspnea is presented in Table 10. Levene’s test of Equality of Error Variance and Box’s Test of Equality of Covariance Matrices suggested that the assumptions were violated (Table 12). Mauchly’s Test of Sphericity was violated as indicated by the $p = 0.00$ however, this multivariate analysis does not require sphericity. Wilks’ Lambda for interaction effect was not significant at $p = 0.343$ however, there was a statistically significant effect for time $p = 0.000$ with a large effect size (Partial Eta Squared = 0.228). The between subject effects are significant at the $p = 0.02$ level.

![Estimated Marginal Means of Dyspnea](image)

**Figure 14** Plot of Pretest and Posttest of Dyspnea across Remote Monitoring Intent to Treat
### Table 12 Summary of Results of Key Statistical Assumptions

<table>
<thead>
<tr>
<th></th>
<th>Levene's Test of Equality of Error Variance</th>
<th>Box's Test of Equality of Covariance Matrices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig</td>
</tr>
<tr>
<td>Dyspnea (M1400)</td>
<td>2.219</td>
<td>0.112</td>
</tr>
<tr>
<td>Dyspnea (M1400 DC)</td>
<td>0.677</td>
<td>0.51</td>
</tr>
</tbody>
</table>

### Table 13 Summary of Descriptive Statistics for Intent to Treat and Dyspnea

<table>
<thead>
<tr>
<th></th>
<th>Intent to Treat</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea (M1400)</td>
<td>0</td>
<td>2.18</td>
<td>0.94</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.5</td>
<td>0.535</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>2.46</td>
<td>1.026</td>
<td>56</td>
</tr>
<tr>
<td>Dyspnea (M1400 DC)</td>
<td>0</td>
<td>0.95</td>
<td>0.944</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>1.88</td>
<td>0.991</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1.2</td>
<td>1.034</td>
<td>56</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>160</td>
</tr>
</tbody>
</table>

**Automatic Interaction Detector Analysis: Process**

This analysis used an Automatic Interaction Detector Analysis (AID Dtreg) to strategically detect meaningful relationships amongst a set of predictors. This statistical tool was used to reveal a potentially overlooked relationship between predictor variables that are potentially invaluable to an organization’s attempt to decrease hospital utilization. Following the ANOVA and Path Analysis, Dtreg was used to explain the process portion of the integrated Donabedian Quality Model. The AID Dtreg was used to understand decision-making at the point of care when clinically adverse characteristics were recognized. Since the remote monitoring
system supported clinical decisions related to the symptoms of heart failure, and these data sets suggest no ER visits were due to heart failure symptoms, only hospital readmissions due to heart failure were considered in the analysis. The decision tree analysis used heart failure-related hospital readmissions (HF TIF) as the target variable.

The variables used in this analysis were identified in the OASIS C. CMS incorporates process and outcome measures to assess the health care services provided, measures agency performance over various elements of care, and identifies areas in need of improvement (Niewenhous, 2010). OASIS C included outcomes measures of hospital utilization, denoted by emergency department use without hospitalization and emergency department use with hospitalization (hospital readmission). These questions are intended to reflect the actions taken by the clinical staff when heart failure symptoms were acknowledged. The first step was to identify decision-making options once it has been determined (in Question M1500) that heart failure symptoms were present. Options for questions M1510 include: 0 - No action taken (1510-0); 1 - Patient’s physician (or other primary care practitioner) contacted the same day (1510-1); 2 - Patient advised to get emergency treatment (e.g., calls 911 or go to emergency room) (1510-2); 3 - Implemented physician-ordered patient-specific established parameters for treatment (1510-3); 4 - Patient education or other clinical interventions (1510-4); 5 - Obtained change in care plan orders (1510-5).

A descriptive analysis was performed by SPSS (version 18). Of the 210 included in the entire analysis, 55 were identified as having symptoms of heart failure by OASIS Question M1500 (27 from usual care and 28 from the intervention group). Of those who had symptoms of heart failure, 20 patients (37%) had no hospital readmission and 33 (61.1%) experienced at least
one hospital readmission, leaving one participant with a hospital readmission that was not assessed by the clinician prior to readmission.

Thirdly, while a correlational analysis was performed by SPSS to determine if there was a strong correlation among decision-making variables, none were noted. Lastly, an Automatic Interaction Detector Analysis, using DTreg, was used to identify how decision-making predicted hospital readmissions. The AID suggested that the most frequent clinician decision made upon finding of a heart failure symptom was to send to the hospital. Data suggest that 51 participants had symptoms of heart failure. Participants that were advised to go to the ER had a 1.00 probability of doing so, and those who were instructed otherwise had a 0.37 probability of hospital readmission. Among participants who experienced a hospital readmission, there was 0.50 probability that patient education or other clinical intervention was implemented prior to the admission. If no clinical education or intervention was received then there was a 0.67 probability of notifying the patients’ physicians the same day. Data suggests that other clinicians’ options to mitigate hospital readmissions were not used significantly in this sample. Total variance explained by the model was 47.12 percent. See Figure 15 and Table 14.
Figure 15. Dtreg Analysis of the Effects of Clinical Decision-making on Hospital Utilization
### Table 14 Results of the Automatic Interaction Detector Analysis Dtreg

<table>
<thead>
<tr>
<th>Variable of importance</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient advised to get emergency treatment (e.g., call 911 or go to emergency room)</td>
<td>100</td>
</tr>
<tr>
<td>Patient's physician (or other primary care practitioner contacted the same day)</td>
<td>12.271</td>
</tr>
<tr>
<td>Patient education or other clinical interventions</td>
<td>10.737</td>
</tr>
</tbody>
</table>

### Structural Equation Modelling

Structural Equation Modelling was used to provide a statistical analysis and visual representation of the interaction between structure and process and its influence on outcomes (as defined by cost and health outcomes). Model criteria included the examination of the solution, measure of overall fit, and detailed assessment of fit. Examination of the solution determines if the parameters are the right sign and size, squared multiple correlations are reasonable, and measurement errors are reasonable. Overall fit uses chi-square ratio, and RMSEA <0.04, CFI > 0.9, GFI > 0.9, and AGFI > 0.9. The goodness of fit index measures the degree to which the amount of variance and covariance can be accounted for by the model. The AGFI is the GFI, but also accounting for degree of freedom. The root means square area (RMSEA) of approximation measures the discrepancy in fit per degrees of freedom. P-value > 0.5 allows the inquirer to accept the null that the model fits the data. Detailed assessment of the fit using modification indices was used to determine the lack of model fit. First, a measurement model was proposed to examine the interaction, if any, between process of care (decision-making) and structure (remote
monitoring). Process of care refers to decision-making as indicated by M1510 from the OASIS. Structure was conceptualized as social environment (M1100), social support (M2100), and remote monitoring. The measurement model was assigned a regression weight of one to lambda for each latent exogenous variable. Modification indices were used to identify the sources for model improvement. Figure 16 shows the proposed model and Figure 17 displays the revised model. While Table 16 indicates good model fit, the model suggests little interaction between structure (remote monitoring) and process of care (estimate = -0.001, S.E = 0.002, C. R. = -0.415, P = 0.678). A comparative summary of the standardized estimates are displayed in Table 15.

Figure 16 Proposed Measurement Model of Structure and Process
Figure 17 Revised Measurement Model of Structure and Process

Table 15 Summary of Standardized Estimates of Structure and Process Model

<table>
<thead>
<tr>
<th>Node</th>
<th>Original Estimates</th>
<th>Revised Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>@15105</td>
<td>Process</td>
<td>0.699</td>
</tr>
<tr>
<td>@15104</td>
<td>Process</td>
<td>0.686</td>
</tr>
<tr>
<td>@15103</td>
<td>Process</td>
<td>0.57</td>
</tr>
<tr>
<td>@15102</td>
<td>Process</td>
<td>0.219</td>
</tr>
<tr>
<td>@15101</td>
<td>Process</td>
<td>0.495</td>
</tr>
<tr>
<td>@15100</td>
<td>Process</td>
<td>-0.087</td>
</tr>
<tr>
<td>M2110</td>
<td>Structure</td>
<td>0.56</td>
</tr>
<tr>
<td>ITT</td>
<td>Structure</td>
<td>0.275</td>
</tr>
<tr>
<td>M1100</td>
<td>Structure</td>
<td>-0.332</td>
</tr>
</tbody>
</table>
Table 16 Goodness of Fit Statistics for Structure Process Model

<table>
<thead>
<tr>
<th>Fit Indices</th>
<th>Criterion</th>
<th>Original Model</th>
<th>Revised Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared</td>
<td>Low</td>
<td>48.903</td>
<td>23.87</td>
</tr>
<tr>
<td>Pvalue</td>
<td>&gt; 0.05</td>
<td>0.004</td>
<td>0.411</td>
</tr>
<tr>
<td>DF</td>
<td>≥ 0</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>x2/df</td>
<td>≥ 0</td>
<td>1.881</td>
<td>1.038</td>
</tr>
<tr>
<td>RMSEA</td>
<td>≤ 0.04</td>
<td>0.065</td>
<td>0.013</td>
</tr>
<tr>
<td>CFI</td>
<td>≥ 0.90</td>
<td>0.817</td>
<td>0.995</td>
</tr>
<tr>
<td>GFI</td>
<td>≥ 0.90</td>
<td>0.952</td>
<td>0.976</td>
</tr>
<tr>
<td>AGFI</td>
<td>≥ 0.90</td>
<td>0.917</td>
<td>0.953</td>
</tr>
</tbody>
</table>

Secondly, a measurement model of cost and health was proposed in Figure 18. The measurement model was assigned a regression weight of one to lambda for each latent exogenous variable. The model was revised (Figure 19) based on modification indices. Cost was conceptualized as agency cost (ACost), net HHRG, and skilled nursing visits (TotalVisits). Health outcome was defined as hospital readmission (TotalRA), emergency department visit (TotalER), and dyspnea (M1400DC). Table 17 shows standardized estimates of the original and revised models.

Figure 18 Proposed Measurement Model of Health and Cost Outcomes
Table 17 Summary of Standardized Estimates of Health and Outcomes Model

<table>
<thead>
<tr>
<th>Metric</th>
<th>Original Estimate</th>
<th>Revised Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>TotalVisits</td>
<td>F1 1.045</td>
<td>1.044</td>
</tr>
<tr>
<td>NetHHRG</td>
<td>F1 0.727</td>
<td>0.731</td>
</tr>
<tr>
<td>ACosts</td>
<td>F1 0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>TotalRA</td>
<td>Health 0.568</td>
<td>0.564</td>
</tr>
<tr>
<td>TotalER</td>
<td>Health 0.135</td>
<td>0.144</td>
</tr>
<tr>
<td>M1400DC</td>
<td>Health 0.77</td>
<td>0.783</td>
</tr>
</tbody>
</table>
Table 18. Summary of Goodness of Fit Statistics of Outcomes Model

<table>
<thead>
<tr>
<th>Fit Indices</th>
<th>Criterion</th>
<th>Original Model</th>
<th>Revised Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Squared</td>
<td>Low</td>
<td>13.282</td>
<td>3.84</td>
</tr>
<tr>
<td>Pvalue</td>
<td>≥ 0.05</td>
<td>0.15</td>
<td>0.798</td>
</tr>
<tr>
<td>DF</td>
<td>≥ 0</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>x2/df</td>
<td>≥ 0</td>
<td>1.476</td>
<td>0.549</td>
</tr>
<tr>
<td>RMSEA</td>
<td>≤ 0.04</td>
<td>0.048</td>
<td>0</td>
</tr>
<tr>
<td>CFI</td>
<td>≥ 0.90</td>
<td>0.994</td>
<td>1</td>
</tr>
<tr>
<td>GFI</td>
<td>≥ 0.90</td>
<td>0.98</td>
<td>0.994</td>
</tr>
<tr>
<td>AGFI</td>
<td>≥ 0.90</td>
<td>0.953</td>
<td>0.982</td>
</tr>
</tbody>
</table>

Based on the revised measurement models of exogenous and endogenous variables, a covariance structural model was used to explain the relationship between the latent endogenous and latent exogenous factors, as seen in Figure 20. Modification indices made no significant suggestions for improvement to the model, therefore a revised model was not indicated. Summary of the estimates are presented in Table 19.

Figure 20 Proposed Measurement Model of the Structure and Process Influence on Outcomes
Table 19 Summary of Standardized Estimates of Structure and Process Influence on Outcomes Model

<table>
<thead>
<tr>
<th></th>
<th>Standardized Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>Process</td>
</tr>
<tr>
<td>Health</td>
<td>Process</td>
</tr>
<tr>
<td>F1</td>
<td>Structure</td>
</tr>
<tr>
<td>Health</td>
<td>Structure</td>
</tr>
<tr>
<td>TotalVisits</td>
<td>F1</td>
</tr>
<tr>
<td>NetHHRG</td>
<td>F1</td>
</tr>
<tr>
<td>ACosts</td>
<td>F1</td>
</tr>
<tr>
<td>TotalRA</td>
<td>Health</td>
</tr>
<tr>
<td>TotalER</td>
<td>Health</td>
</tr>
<tr>
<td>M1400DC</td>
<td>Health</td>
</tr>
<tr>
<td>@15105</td>
<td>Process</td>
</tr>
<tr>
<td>@15104</td>
<td>Process</td>
</tr>
<tr>
<td>@15103</td>
<td>Process</td>
</tr>
<tr>
<td>@15102</td>
<td>Process</td>
</tr>
<tr>
<td>@15101</td>
<td>Process</td>
</tr>
<tr>
<td>@15100</td>
<td>Process</td>
</tr>
<tr>
<td>M1100</td>
<td>Structure</td>
</tr>
<tr>
<td>M2110</td>
<td>Structure</td>
</tr>
<tr>
<td>ITT</td>
<td>Structure</td>
</tr>
</tbody>
</table>

Cost Outcomes Ratio

The calculation of average cost per participant was performed. Cost data, such as the number of skilled nursing visits, cost per nursing visit, net HHRG, and the intervention program costs, were obtained through the billing department of the agency and the clinical record. An intervention program cost includes equipment, monitoring, maintenance, marketing, and additional personnel cost, approximately $300 per patient on remote monitoring. The average annual program costs are seen in Table 20. Average annual program costs were calculated from 2012 actual program cost per month and 2013 program cost from January to October. November
and December 2013 was then estimated from the given data. Annual program costs were averaged for the 2012 and 2013 program.

Table 20 Summary of Average Annual Remote Monitoring Program Cost

<table>
<thead>
<tr>
<th></th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Cost</td>
<td>$179,151</td>
</tr>
<tr>
<td>Hardware, monitoring, warranty costs</td>
<td></td>
</tr>
<tr>
<td>Additional Personnel + benefits</td>
<td>$284,230</td>
</tr>
<tr>
<td><strong>Gross program annual costs</strong></td>
<td><strong>$472,381</strong></td>
</tr>
</tbody>
</table>

An independent t-test was used to compare group means of number of skilled nursing visits and agency costs in two separate analysis. The advantage of using a robust test was that a fairly accurate probability could be obtained even if the populations do not have the assumed characteristics of normal distribution and random sampling (Spatz, 2005). An independent t test was performed to examine costs between usual care and remote monitoring groups.

Statistically significant differences were indicated for skilled nursing visits and agency costs, p value of 0.002 and 0.000 respectively. Statistical significance was not indicated for Net HHRG, p = 0.920. Results of the independent t test are presented in Table 13.
Table 21 Summary of Results of Independent T Test for Remote Monitoring

<table>
<thead>
<tr>
<th></th>
<th>Usual Care</th>
<th></th>
<th>Intervention</th>
<th></th>
<th>Levene's Test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=105)</td>
<td>(n=105)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Std Deviation</td>
<td>Mean</td>
<td>Std Deviation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skilled Nursing Visit</td>
<td>13.05</td>
<td>8.006</td>
<td>17.06</td>
<td>10.009</td>
<td>0.072</td>
<td>0.0020</td>
</tr>
<tr>
<td>Net HHRG</td>
<td>$2,643.76</td>
<td>1600.11</td>
<td>$2,624.13</td>
<td>1189.06</td>
<td>0.011</td>
<td>0.9200</td>
</tr>
<tr>
<td>Agency Cost</td>
<td>$521.90</td>
<td>320.26</td>
<td>$982.29</td>
<td>403.97</td>
<td>0.072</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
The benefits of the program refer to the net program costs and number of skilled visits reflected in each group. The average cost per skilled nursing visit is $40. The average number of skilled nursing visits in the comparison group was 13.05 visits, and the intervention group was 17.06 visits. Net HHRG was actual payments received per episode of care per patient. Average Net HHRG was $2643.76 and $2624.12, the comparison and intervention group respectively.

Average cost difference (exp. – comparison)/Difference in changes of an outcome measure between the exp. & comparison groups;

ER: $982.29 - $521.90/2 (where 2 ER visits is the difference in outcomes between the exp. & comparison groups) = $230.195

Total HF TIF: $982.29 - $521.90/1 (where 1 HA visits is the difference in outcomes between the exp. & comparison groups) = $460.38

Monthly cost due to additional benefit of decreased EDV and HF TIF is $230.195. Thus, the remote monitoring was not a cost effective alternative to usual care. Based on the following decision-making rule:

(1) If the two interventions of care being considered are equal in outcomes, then one considers the least costly option.

(2) If both methods of care are equal in cost, then one considers the most effective intervention program.

(3) However, if the most costly method produces the better outcomes, then one must consider incremental cost effectiveness.
One should consider Option 1. The agency does not overcome the cost of the remote monitoring program and statistically insignificant differences in hospital utilization outcomes suggest that other alternatives should be considered.

**Chapter Summary**

Prior to hypothesis testing, propensity score analysis using R software was performed to balance the observed covariates between the two groups. Hypothesis testing was performed to systematically test the statistical significance of the findings. First, a descriptive analysis was performed to understand the sample characteristics and the performance of the agency in consideration to national norms. Data suggest that while all-cause EDV visits were below national average, all cause hospital readmissions were well above national average. Hospital readmissions related to heart failure were slightly above the national average of 16 to 23 percent. Path Analysis was incorporated into this study to further elucidate the influence of the intent to treat in remote monitoring on hospital utilization.

There was no statistically significant difference at the p < 0.05 level for hospital utilization as defined by emergency room visits. F (4, 205) = 0.211, p = 0.932. Therefore, we fail to reject the null and consider that there is no statistically significant decrease in emergency room visits. Statistical significance suggested a difference in pre and posttest measures for dyspnea. The intensity of remote monitoring indicated between group differences for dyspnea.

A structural equation model suggests that remote monitoring had little interaction with process of care. Therefore the interaction of structure and process was not significant influential in the outcomes of care.
Results of the t test suggested that there was no statistically significant difference at the 
p< 0.05 level. Therefore, we fail to reject the null hypothesis and consider that there is no 
difference in the Net HHRG between usual care and remote monitoring. Because statistical 
significance was noted for agency cost and skilled nursing visits, we therefore reject the null and 
consider that there is a difference between usual care and remote monitoring groups.

Due to the two interventions of care being considered equal in outcomes, it stands to 
reason that one considers the least costly option. Therefore, due to high cost of remote 
monitoring, the data suggest that standard care be considered.
CHAPTER FIVE: DISCUSSIONS AND CONCLUSIONS

The Heart Failure Association of America warns that HF affects nearly five million
Americans and is the only major cardiovascular disease that is increasing among people aged 65
and older. This study represented an attempt to understand the potential effect of remote
monitoring in patients with heart failure. In doing so, this study sought to answers three
questions:

1. To what extent does the cost per outcome justify the use of remote monitoring in
   patients with HF?
2. To what degree is remote monitoring in home care used to affect positive change in
   the process of care?
3. In an effort to decrease the costs of accessible quality care, can remote monitoring be
   used as an intervention strategy to affect positive changes in health and cost outcomes
   among patients with HF?

To answer these questions, seven hypotheses were presented and six were tested. H2b was not
tested due to no EDV related heart failure in this data set. Table 21 is a summary of the
hypotheses and results.

Results of Hypothesis Testing

H1: When structural factors are held constant, better care structure leads to better
clinical process.

H1a: There is a statistically significant difference in skilled nursing utilization between
the standard of care and remote monitoring care groups in patients with HF.
H1b: There is a statistically significant difference in Net HHRG (net income) between the standard of care and remote monitoring care groups in patients with HF.

H1c: There is a statistically significant difference in agency costs between the standard of care and remote monitoring care groups in patients with HF.

Hypothesis H1 sought to answer research question number one: This analysis involved examining the number of skilled nursing visits, net HHRG, and agency administrative costs. Results suggested a statistically significant difference in skilled nursing visits and administrative costs that favored the usual care program. The remote monitoring group had a statistically significant increase in the number of skilled nursing visits and administrative costs. The average agency profit per patient was not statistically significant between the groups. The agency experienced similar average income per patient. Thus, the remote monitoring group increased the financial burden on the agency, with no change in income to offset the cost of the program. Fiscally, the remote monitoring program was not advantageous as compared to the usual care group; from the cost outcomes ratio analysis, the cost per outcome does not justify the use of remote monitoring.

Hypothesis two sought to answer question two of the study.

H2: When structural factors are held constant, better care process leads to better clinical outcomes.

H2a: There is a positive relationship between decision-making and rate of hospital readmissions in patients with HF.

H2b: There is a positive relationship between decision-making and rate of emergency department visits in patients with HF.
The AID: Dtreg analysis suggested that decision-making by the clinician was a critical factor in hospitalizations. The data suggested that patient education, clinical interventions, and physician notification prior to hospitalization were not significantly used. Clinician behavior was contrary to the purposes of remote monitoring; the use of data to enact early interventions to mitigate the need for hospital utilization was not demonstrated in this study.

H3: The structure positively affects the process of care that will lead to better care outcomes.

H3a: Remote monitoring positively affects the process in home health care that will lead to statistically significant differences in health outcomes for patients with HF.

H3b: Remote monitoring positively affects the process will lead to statistically significant differences in cost outcomes for patients with HF.

No significant difference was noted in remote monitoring and usual care groups. Results suggested that remote monitoring does not statistically lead to a decrease in heart failure-related hospital readmissions and all-cause emergency department visits. Data also suggested that all heart failure-related emergency department visits led to hospital readmissions. Statistical significance revealed differences in pre- and posttest measures for dyspnea, but no difference between groups were noted. While participants who completed 51 to 75 percent of remote monitoring also demonstrated a relative increase in the average number of heart failure symptoms, no conclusion can be drawn from this result. The sample size for this group was relatively small. Due to low sample size across compliance rates, no conclusions can be made about compliance and hospitalization risks.
# Table 22 Summary of Hypothesis and Results

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Relationship</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure and Process</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1: When structural factors are held constant, better care structure leads to better clinical process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₁a: There is a statistically significant difference in skilled nursing utilization between the standard of care and remote monitoring care groups in patients with HF.</td>
<td>(+)</td>
<td>Higher skilled nursing utilization was noted in the remote monitoring group</td>
</tr>
<tr>
<td>H₁b: There is a statistically significant difference in Net HHRG (net income) between the standard of care and remote monitoring care groups in patients with HF.</td>
<td>(+)</td>
<td>No difference was noted in net HHRG between groups</td>
</tr>
<tr>
<td>H₁c: There is a statistically significant difference in agency costs between the standard of care and remote monitoring care groups in patients with HF.</td>
<td>(+)</td>
<td>Higher skilled nursing utilization was noted in the remote monitoring group</td>
</tr>
<tr>
<td><strong>Process and Outcomes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H2: When structural factors are held constant, better care process leads to better clinical outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂a: There is a positive relationship between decision-making and rate of hospital readmissions in patients with HF.</td>
<td>(+)</td>
<td>A relationship was found between hospital readmission and clinician recommendation</td>
</tr>
<tr>
<td>H₂b: There is a positive relationship between decision-making and rate of emergency department visits in patients with HF.</td>
<td>(n/a)</td>
<td>This could not be tested as no EDV due to HF was detected</td>
</tr>
<tr>
<td><strong>Structure - Process Interaction Influence on Outcomes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H3: The structure positively affects the process of care will lead to better care outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₃a: Remote monitoring positively affects the process in home health care will lead to statistically significant differences in health outcomes for patients with HF.</td>
<td>(+)</td>
<td>Interaction of structure and process resulted in little influence on health outcomes</td>
</tr>
<tr>
<td>H₃b: Remote monitoring positively affects the process in home health care will lead to statistically significant differences in cost outcomes for patients with HF.</td>
<td>(+)</td>
<td>Interaction of structure and process resulted in little influence on cost outcomes</td>
</tr>
</tbody>
</table>

Statistically Significant at p > 0.05; H3
Statistically Significant at p < 0.05; H1, H2
Significance of Results and Theoretical Importance

The Donabedian Quality Model offers a framework for the impact of structure on process, process on outcomes, and the interaction of structure and process on outcomes. By embedding a formative analysis, offered by the SPO Model, remote monitoring was offered as a technological infrastructure or input to support an intervention program. In this manner, each component of the program was conceptualized and examined as a critical component to improve quality outcomes of patient with HF.

Structure and Process

H1: When structural factors are held constant, better care structure leads to better clinical process.

In this study, structure had little positive influence on the care process. The structural inputs as seen in the SPO Model (Figure 2) and the results of this study suggest that the inputs into the system had little influence on the process. The addition of a technological structure complicated the process through the increased number of skilled nursing visits, increased agency costs, and little change in net income to the organization. This increased the cost of care confounded agency cost through an increase in intensity of service utilization without offsetting agency investment into the technology.

Process and Outcomes

H2: When structural factors are held constant, better care process leads to better clinical outcomes.
The data in this study suggest that the clinical process had a significant influence on the outcome. This supports Donabedian’s framework of process influence on outcomes. However, the outcomes were not favorable due to an inadequate process of care. While other options were available that might have facilitated favorable outcomes, they were not implemented. Based on the data, clinicians in this facility showed little evidence that patient education, clinical interventions, or physician contact were initiated before hospital recommendations. This has significant implications for the need for clinical education on the influence of process of care on outcomes. While structure may influence the process, the clinicians’ decision to harness the strength of technology (timely physiological information) in the clinical process was critical to hospital utilization. When the clinical decision-making favored an increase in the complexity of care, there was a high utilization of hospital services.

_H3: Interaction of Structure and Process on Outcomes_

The structure positively affects the process of care will lead to better care outcomes. The lack of influence of structure on process was problematic for this study. Remote monitoring had little influence on the process of care. However, the model suggest that process has a greater influence on cost and health care outcomes, than do structure. Health information technology is a resource intensive investment, therefore, one should ask – to what degree can process be improved without the added financial burden of remote monitoring?

The results of the study, using the Donabedian Models, suggested that the structure was inadequate to affect change in outcomes. The SPO model suggested that processes are critical to the success of the remote monitoring program. However, more studies are needed to determine the interaction of structure and process on outcomes.
Practical Use

Clinical Use. Fundamental to efficacious clinical decisions are information exchange (Feldman & Horan, 2011). Effective information exchanges in health care can enhance collaboration for decision-making and care coordination (Feldman & Horan, 2011). Health information technology (HIT) has the potential to increase the utilization of organizational resources by enabling practitioners to work together with reliable and valid health data (Nevo & Wade, 2010). Under this framework, the introduction of information technology in health care is critical to health care reform. The information clinicians obtained from it should be considered in the care process that favors alleviation of symptoms at lower levels of care.

The role of nursing care in heart failure management, whether in hospital or community based care, is critical quality outcome. When patients have heart failure symptoms, it is important for clinicians to recognize the signs and symptoms, and be able to ascertain and implement the most appropriate clinical intervention. The nursing staff must be able to collaborate with team members and physicians to provide the best possible care. The status of the health care system deems that sending patients to the hospital for symptom management is not acceptable. Clinical decisions are related to quality and cost, and quality and cost are interrelated themselves (Donabedian, 1983).

Collaborative Practice. Collaborative practice in the home health setting is challenging. The clinicians are relatively autonomous as they work independently in patient’s home. Contacts with other clinicians occur during staff meetings, telephone, or email communications, which may inhibit timely care if clinical questions remain unresolved for prolonged periods. Therefore, the level of care is highly dependent upon the skill of the treating clinician. Geographic barriers
inherent between the home care providers and the medical offices increase the difficulty for alerting physicians, as many times a phone call must be made (Guggiano, Brown, Hristidis, & Page, 2013). Therefore, potentially urgent matters may not be immediately addressed while home care clinicians await orders from the treating doctor. While remote monitoring may provide timely information and alert staff to physiological deterioration, changes in plan of care as a result of this information, must be cleared through the physicians who are likely unavailable immediately to address these issues. This delays the coordination of care that remote monitoring is stipulated to support. The literature suggested that while health information technology may increase the availability of information, the flow of information amongst providers may be inadequate (Mäkelä et al., 2013). The integration of remote monitoring and other smart home technologies in home care suggested that the process of care (and communication) among home care clinicians and physician office practices must be adequately addressed.

Accountable Care Organizations. Recent legislation such as the Hospital Readmission Penalty discourages hospital overutilization. While this legislation primarily penalizes hospitals, home health agencies with high hospital readmission rates will not be viable partners with hospitals, if hospital objectives cannot be met. Therefore, while it is laudable to adopt intervention programs to decrease hospital readmissions, this study suggests that a greater focus on the interaction between technology and clinicians should be emphasized to promote better care processes.
Policy Relevance

Influenced by the passage of the Patient Protection and Accountable Care Act (PPACA) and Health Information Technology for Economic and Clinical Health Act (HITECH), the health care system is under pressure to control costs (Blumenthal, 2009). Cost control will be achieved with interventions that mitigate preventable health complications (Orszag & Emanuel, 2010). Ten percent of patients account for 64 percent of cost, and many of these patients are diagnosed with heart failure, diabetes, and hypertension (Orszag & Emanuel, 2010). Therefore, the exploration of remote monitoring to facilitate quality management of these ailments is reasonable.

Technology, while it shapes human action making some actions possible, requires the deliberate action and support from health care professionals (Greenhalgh & Swinglehurst, 2011). Used appropriately, remote monitoring should enhance delivery care models, processes, and patient care team interactions (Cheitlin, 2012). HITECH and PPACA recognize that data collection is not an end in itself, but the information it provides should be implemented to efficiently allocate resources (Buntin et al., 2010; Classen & Bates, 2011). This study suggests that the mere adoption of technology does not increase efficiency and the effectiveness of health care organizations to deliver care. Further examination of the process of clinical care raises concerns about the utility of the information and resultant decisions. This study suggests that preoccupation with technology should be shifted to the evaluation of the process of providing medical care.

Recognizing these ideals, CMS defines meaningful use of technology to:

1. Improve quality, safety efficiency, and reduce health disparities,
2. Engage patient and families in their health care, 
3. Improve care coordination, 
4. Improve population and public health, and 
5. Maintain privacy and security.

Meaningful use of remote monitoring requires that valid health information be submitted electronically to affect positive change in clinical processes and outcomes. Therefore, the health information derived from remote monitoring should be influential in clinical strategies that promote early interventions before hospital utilizations are necessary.

Appendix F provides a summary of recent legislation to support the use of advance communication and health information technology. From this table, one sees a relatively large amount of fiscal resources devoted to the clinical use of advance information technology.

**Methodological Rigor**

Prior studies have examined the structure of remote monitoring and its direct influence on quality outcomes. Prospective studies have been plagued with limitations due to sample size. A high mortality rate (drop out) of participants was noted, leaving an inadequate effect size to validate the findings. Other studies have noted that the Hawthorne Effect may be an issue to those on the remote monitoring. Clinicians were noted to provide more clinical care and patient education to the remote monitoring group than the control group. As a retrospective study, opportunities for inequalities are lessened. Propensity score analysis was used to decrease selection bias and inequalities among the groups. Dtreg was used to examine the influence of decision-making on hospital utilization.
Limitations

This retrospective case control design does not allow for true random assignment. While propensity score matching and analysis were used to alleviate selection bias, interpretation of the results should be cautiously considered. Other variables of interest may include health literacy and patient compliance and their effects on patient quality outcomes.

Hospital Utilization Outcomes. External validity of the study was limited due to the high rate of hospital readmissions and the low rate of emergency department visits found in this data set. Although Medicare stipulates that home health care admission is required within 24 hours of hospital discharge, extenuating circumstances may dictate that home care admissions were prolonged. Although secondary diagnosis, readmission diagnosis, and EDV diagnosis was considered in this study, the influence of exacerbating co-morbidities is difficult to control.

Cost Outcomes Ratio. The limitations for the cost analysis for this study site are recognized. The results of the study are limited in their generalizability. External validity was limited in this study due to the fiscal vulnerability of this organization. While a national organization, it has undergone several changes. In 2012, it bought another nationally recognized agency. In late 2013, they were purchased by another agency. This underscores the financial instability of the organization. The variability among organizational structures and processes in the use of remote monitoring among home care agencies also contributes to its lack of external validity. It was difficult to ascertain whether leasing or buying would be more advantageous to the organization, as this agency used leased and purchased monitoring units. The patients’ ability to understand and apply health care instructions may contribute to nursing utilization, as well. This study did not consider health literacy and technology acceptance of remote monitoring or
the number of face-to-face visits with physicians that decreased the need for home nursing care
visits.

Clinical Outcomes. Interval validity and reliability is also called into question as a review of the medical record demonstrated clear inconsistencies between nursing visits. It is questionable whether continuity of care existed between clinicians with discrepancies in addressing similar issues. The data for the study was obtained by the Outcome and Assessment Information Set (OASIS), which is used by CMS to gather patient clinical and functional information. There was potential for variability in ascertaining such information as the ability to respond to questions appropriately is dependent upon skill level of the clinicians, and familiarity with how to answer questions. Clinician education should be uniformly taught to increase the consistency and accuracy in answering OASIS questions. The variability in sample size among the groups suggests that caution should be applied when interpreting the results.

**Recommendation for Future Research**

The clinical and economic impact of heart failure suggests a failing health care system that inadequately addresses the needs of a growing majority. Health care agencies consider viable intervention programs to mitigate such ill effects. Future clinical outcomes studies should consider the New York Functional Classification Scale for its reliability and validity in clinical practice and research as a measure of functional outcome or as a measure of patient classification (Bennett, Riegel, Bittner, & Nichols, 2002; Goldman, Hashimoto, Cook, & Loscalzo, 1981).

The results of the study suggested that mere adoption of technology is clinically ineffective and is economically detrimental to the agency. Future research should emphasize the
process of providing care. The adaptation structuration theory may be used to consider how clinicians use the information for decision-making and collaborate amongst themselves from a socio-technological perspective. Thus, the value of the information gained from remote monitoring derives from the decisions they support. It is generally accepted in medical literature that compliance rate to an intervention program affects hospitalization rate and health care costs. Further research is needed to determine optimal compliance rates for significant changes in quality outcomes with remote monitoring. Methods to increase compliance among patients are also critical to this program. Collaborative scales should be used in future studies to examine the degree to which remote monitoring information enhances patient-clinician and clinician to clinician collaboration.

Cost evaluation studies may consider cost effectiveness analysis. Cost effective research (CER) offers an opportunity for public health initiatives to be supported by solid evidence of their effectiveness. It enhances the decision-making process by identifying which intervention strategies have superior outcomes, reconsiders commonly pursued strategies, and draws attention to underutilized programs (Saver, 2011). Therefore, instead of asking does this work, CER evaluates how different intervention strategies compare to each other. Current studies suggest that the lack of well-functioning remote monitoring programs and inadequate methodological rigor in economic evaluations permeates telehealth studies. Cost effectiveness analysis may be performed with the Markov model. This decision-making model is used to determine the probability of emergency room visits, hospitalization, and mortality in the intervention or comparison group. Costs analysis may include direct medical care and the additional cost of the intervention program. A sensitivity analysis, using incremental cost effectiveness, may account
for assumptions and uncertainties in the model, while considering quality-adjusted life-years (QUALY).

Future studies may also consider a cost-benefit analysis from the user’s perspective. Endpoints to consider may include indirect cost to the system such as a caregiver’s time from work for transportation, and patient visits to the physician’s office.

As the field continues to consider the use of technology in health care, health care professionals and researchers should consider process of care as a patient-centered task, where human performance is valued over tasks-oriented care. The focus on tasks leads professionals to provide care as isolated tasks, where fragmentation of care exists (Walker & Carayon, 2009). This leads to the lack of collaboration of care; hence, patients are moved from one health care setting to another and exacerbations in health status are not resolved at the lower levels of care. The valuing of care process design has led to the term “human performance technology” in health care, replacing the term “clinical process” (Kulhanek & Kulhanek, 2013; Walker & Carayon, 2009). This supports future research in human-factors engineering, pay-for-performance, and total quality management in health information technology (Walker & Carayon, 2009). The adoption of new technologies should accompany a cultural change to support the advantage that technology provides.
APPENDIX A: SIGNIFICANCE OF HOSPITAL READMISSIONS
Significant of Hospital Readmissions

* National health care spending was postulated to be $2.6 trillion FY 2010; 17.7% of GDP
* Hospital Readmissions $17.4 billion out of $102.6 billion in total hospital payments
* 20% of all Medicare beneficiaries are readmitted within 30 days of hospital discharge
* 34% of all Medicare beneficiaries are readmitted within 90 days of hospital discharge

* Hospital Compare Website reveals that 30 day readmission rate for HF remains largely unchanged from 2007 to 2010 (Kosher & Adashi, 2011).
* Department of Health and Human Services strategic plan for 2010-2015 cites payment incentives to reduce readmissions,

* Center for Medicare and Medicaid Services' National Strategy for Quality Improvement in Health Care seeks to decrease readmission rates by 20% by end of 2013 (Kosher & Adashi, 2011); preventing 1.6 million hospitalizations and saving approximately $15 billion
Influence of Heart Failure

* Heart failure is the most common cause of hospitalizations among Medicare recipients, accounting for 1.4 million hospitalizations annually

* Prevalence rate: 5.6 million with 400,000 diagnosed annually

* Congestive Heart Failure, 1/10 die within 30 days of hospitalizations; 1/4 have high readmission rates

* 59% of men and 40% of women are die within 5 years of diagnosis

* FY 2010, indirect and direct costs of Heart failure estimated to be $39.2 billion
APPENDIX C: SUMMARY OF THE LITERATURE OF REMOTE MONITORING EFFECTS ON QUALITY
<table>
<thead>
<tr>
<th>Reference</th>
<th>Diagnosis</th>
<th>Technology</th>
<th>Intervention</th>
<th>Clinical Outcomes</th>
<th>Economic Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antonicelli et al. (2010)</td>
<td>CHF</td>
<td>Home telemonitoring</td>
<td>12 months</td>
<td>Significant decrease in mortality and hospital readmission in TM (P&lt;0.01)</td>
<td>N/A</td>
</tr>
<tr>
<td>Clark et al. (2007)</td>
<td>CHF</td>
<td>Home Telemonitoring; Telephone Support</td>
<td>Systematic Review</td>
<td>Systematic Review. Remote monitoring decrease admission by 21%; mortality by 20%</td>
<td>Reduce Health Care cost</td>
</tr>
<tr>
<td>Finkelstein et al. (2006)</td>
<td>CHF; COPD</td>
<td>Home Telemonitoring; Video Conference</td>
<td>6 month</td>
<td>No significant difference in mortality rates. Significant difference in hospital admissions.</td>
<td>Reduce Health Care cost via decrease admissions, Video $22.11, TM $33.11, and face-to-face $48.27 per visit</td>
</tr>
<tr>
<td>Trappenburg et al. (2008)</td>
<td>COPD</td>
<td>Home Telemonitoring</td>
<td>6 month</td>
<td>Decreased hospital admission; Decreased length of stays</td>
<td>N/A</td>
</tr>
<tr>
<td>Vitacca et al. (2009)</td>
<td>COPD</td>
<td>Telephone</td>
<td>12 months</td>
<td>Decreased hospital admission; decreased ED</td>
<td>33% lower costs for TM</td>
</tr>
<tr>
<td>Willems et al. (2007)</td>
<td>COPD</td>
<td>Home Telemonitoring</td>
<td>12 months</td>
<td>No significant difference in mortality rates. Significant difference in hospital admissions.</td>
<td>N/A</td>
</tr>
<tr>
<td>Bowles et al. (2009)</td>
<td>CHF; Diabetes</td>
<td>Home Telemonitoring; Telephone Support+TM</td>
<td>120 days</td>
<td>No significant difference in mortality rates. Significant difference in hospital admissions.</td>
<td>N/A</td>
</tr>
<tr>
<td>Reference</td>
<td>Diagnosis</td>
<td>Technology</td>
<td>Intervention</td>
<td>Clinical Outcomes</td>
<td>Economic Outcomes</td>
</tr>
<tr>
<td>-------------------</td>
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<td>------------------------------------------------</td>
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<td>------------------------------------------------------------</td>
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</tr>
<tr>
<td>Dansky et al.</td>
<td>Chronic Disease</td>
<td>Home Telemonitoring; One way monitor; two way monitor; video</td>
<td>120 days</td>
<td>No significant difference in mortality rates. Significant difference in hospital admissions.</td>
<td>N/A</td>
</tr>
<tr>
<td>(2008)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jerant et al.</td>
<td>CHF</td>
<td>Home Video; Telephone Support; Outpatient Care</td>
<td>12 months</td>
<td>(+) Readmissions in both intervention groups (-) no between group differences</td>
<td>N/A</td>
</tr>
<tr>
<td>(2001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pare et al.</td>
<td>COPD</td>
<td>Home Telemonitoring</td>
<td>6 months</td>
<td>(+) Readmissions</td>
<td>N/A</td>
</tr>
<tr>
<td>(2006)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polisena et al.</td>
<td>CHF</td>
<td>Home Telemonitoring</td>
<td>Systematic Review</td>
<td>(+) Readmissions (+) Mortality Rate</td>
<td>N/A</td>
</tr>
<tr>
<td>(2010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Home monitoring cuts cardiac readmissions&quot;</td>
<td>CHF</td>
<td>Home Telemonitoring</td>
<td>60 days</td>
<td>(+) Readmissions</td>
<td>N/A</td>
</tr>
<tr>
<td>Tompkins et al.</td>
<td>CHF</td>
<td>Home Telemonitoring</td>
<td>Systematic Review</td>
<td>(-) Readmissions (-) Mortality</td>
<td>(-) Cost Agency</td>
</tr>
<tr>
<td>(2010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dang et al.</td>
<td>CHF</td>
<td>Home Telemonitoring</td>
<td>Systematic Review</td>
<td>(+) Readmissions (+) Mortality Rate</td>
<td>N/A</td>
</tr>
<tr>
<td>(2009)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>


APPENDIX D: SUMMARY OF COST ANALYSIS OF REMOTE MONITORING
### Summary of Cost Analysis of Remote Monitoring

<table>
<thead>
<tr>
<th>Reference</th>
<th>Diagnosis</th>
<th>Economic Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whitten et al. (2002)</td>
<td>HF; Systematic Review</td>
<td>Negative - Agency/Health Care</td>
</tr>
<tr>
<td>Dansky et al. (2001)</td>
<td>HF; Diabetes</td>
<td>Negative - Agency level; Positive - Health care costs</td>
</tr>
<tr>
<td>Seto, (2008)</td>
<td>HF; Systematic Review</td>
<td>Negative - Agency level; Positive - Health care costs</td>
</tr>
<tr>
<td>Tompkins et al. (2010)</td>
<td>HF</td>
<td>Negative - Agency level;</td>
</tr>
<tr>
<td>Vitacca et al. (2009)</td>
<td>COPD</td>
<td>Positive - Agency level; Positive - Health care costs</td>
</tr>
</tbody>
</table>
APPENDIX E: OPERATIONALIZATION OF STUDY VARIABLES
Operationalization of Study Variables

<table>
<thead>
<tr>
<th>Construct</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Endogenous</strong></td>
<td></td>
</tr>
<tr>
<td>Heart Failure</td>
<td></td>
</tr>
<tr>
<td>Hospital Readmissions</td>
<td>HA TIF 0 = None, 1 = Yes</td>
</tr>
<tr>
<td>Emergency Visits</td>
<td>ED 0 = None, 1 = Yes</td>
</tr>
<tr>
<td>Marital Status</td>
<td>MS 1 = Single, 2 = Married, 3 = Widowed, 4 = Divorced</td>
</tr>
<tr>
<td>Intent to Treat</td>
<td>0 = 0 percent completion of any remote monitoring, 1 = .001 to .25 completion of remote monitoring, 2 = .26 to .50 of remote monitoring completion, 3 = .51 to .75 completion of remote monitoring; and 4 = .76 to 1.00 completion</td>
</tr>
<tr>
<td><strong>Exogenous</strong></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Age in years</td>
</tr>
<tr>
<td>Race</td>
<td>1 = White, 2 = Black, 3 = Hispanic, 4 = Asian</td>
</tr>
<tr>
<td>Gender</td>
<td>1 = Male, 2 = Female</td>
</tr>
<tr>
<td>Chronic Obstructive Pulmonary Disease</td>
<td>COPD See 1005 in Appendix G</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>CHF See 1005 in Appendix G</td>
</tr>
<tr>
<td>Social Environment</td>
<td>M1100 See M1100 in Appendix G</td>
</tr>
<tr>
<td>Social Support</td>
<td>M2110 See M2110 in Appendix G</td>
</tr>
<tr>
<td>Construct</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Clinical Acuity</td>
<td>level of clinical status as determined by OASIS scoring 0 to 20 (low to high)</td>
</tr>
<tr>
<td>Functional Acuity</td>
<td>level of functional status as determined by OASIS scoring 0 to 20 (low to high)</td>
</tr>
<tr>
<td>M1034 Overall Status</td>
<td>See M1034 in Appendix G</td>
</tr>
<tr>
<td>M1400 Short of Breath</td>
<td>See M1400 in Appendix G</td>
</tr>
<tr>
<td>M1500 Symptom of CHF</td>
<td>See M1500 in Appendix G</td>
</tr>
<tr>
<td>M1860 Ambulation</td>
<td>See M1860 in Appendix G</td>
</tr>
<tr>
<td>M1700</td>
<td>See M1700 in Appendix G</td>
</tr>
<tr>
<td>M1730</td>
<td>See M1730 Appendix G</td>
</tr>
</tbody>
</table>
APPENDIX F: SUMMARY OF HEALTH LEGISLATION TO SUPPORT HEALTH QUALITY AND TECHNOLOGY USE
## Summary of Legislation for Health Care Information Technology Use

<table>
<thead>
<tr>
<th>Initiatives</th>
<th>Enacted/Mandated</th>
<th>Provisions</th>
<th>Fiscal Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Protection and Affordable Care Act</td>
<td>March 23, 2010 by President Barack Obama and the 111th United States Congress</td>
<td>* Hospital Readmission Reductions- Alter means of payment in efforts to improve quality and eliminate high cost areas * Supports Health Information Technology infrastructure.</td>
<td>$20 billion in health information technology infrastructure; $40,000 - $60,000 for physicians demonstrating meaningful use; hospital eligible for &gt; $1 million</td>
</tr>
<tr>
<td>Health Information Technology for Economic and Clinical Act</td>
<td>Mandated by American Recovery and Reinvestment Act of 2009</td>
<td>* Funding support for Health Information Infrastructure</td>
<td></td>
</tr>
<tr>
<td>Beacon Community Cooperative Agreement Program</td>
<td>Mandated by American Recovery and Reinvestment Act of 2009</td>
<td>* Promulgates meaningful use of Health Information Technology</td>
<td>$255.3 million grant, along with additional $15 million in evaluation and technical assistance to fund education</td>
</tr>
<tr>
<td>Regional Extension Center and State Health Information Exchange</td>
<td>HITECH Initiative</td>
<td>*Support for exchanging information across health care systems</td>
<td>Thus far, $547,703,428 awarded to 56 states, eligible territories, and qualified state designated entities</td>
</tr>
<tr>
<td>National Pilot Program on Payment Bundling (NPPPB)</td>
<td>Mandated by ACA Section 3023</td>
<td>* Bundling of Medicare payments into a single comprehensive fee for an episode of care</td>
<td>5 year voluntary effort with CMS oversight</td>
</tr>
</tbody>
</table>

108
<table>
<thead>
<tr>
<th>Initiatives</th>
<th>Enacted/Mandated</th>
<th>Provisions</th>
<th>Fiscal Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independence at Home Demonstration Program (IAHP)</td>
<td>Mandated by ACA, Section 3024</td>
<td>* Home Based Primary care teams directed by physicians or nurse practitioners for home bound seniors</td>
<td>3 years $25 million program</td>
</tr>
<tr>
<td>Hospital Readmission Reduction Program (HRRP)</td>
<td>Mandated by ACA Section 3025</td>
<td>*Aligns payments with quality outcomes, projected to begin FY 2013</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Reduce hospital admissions by targeting quality and safety of care transitions between inpatient and outpatient arenas. Supports partnerships between hospitals and community based organizations.</td>
<td>5 year-$500 million program</td>
</tr>
<tr>
<td>Community-Based Care Transition Program (CCP)</td>
<td>Mandated by ACA, Section 3026</td>
<td>*Reduce hospital admissions by targeting quality and safety of care transitions between inpatient and outpatient arenas. Supports partnerships between hospitals and community based organizations.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX G: OASIS DATA SET INCLUDED IN THIS STUDY
Race/Ethnicity:
1 - American Indian or Alaska Native
2 - Asian
3 - Black or African-American
4 - Hispanic or Latino
5 - Native Hawaiian or Pacific Islander
6 - White

From which of the following Inpatient Facilities was the patient discharged during the past 14 days? (Mark all that apply.)

- 1 - Long-term nursing facility (NF)
- 2 - Skilled nursing facility (SNF / TCU)
- 3 - Short-stay acute hospital (IPP S)
- 4 - Long-term care hospital (LTCH)
- 5 - Inpatient rehabilitation hospital or unit (IRF)
- 6 - Psychiatric hospital or unit
- 7 - Other (specify)

NA - Patient was not discharged from an inpatient facility [Go to M1016]

Inpatient Discharge Date (most recent):
__ __ / __ / __ __ __ __
month / day / year

Rate the degree of symptom control for the condition listed in Column 1 using the following scale:
0 - Asymptomatic, no treatment needed at this time
1 - Symptoms well controlled with current therapy
2 - Symptoms controlled with difficulty, affecting daily functioning; patient needs ongoing monitoring
3 - Symptoms poorly controlled; patient needs frequent adjustment in treatment and dose monitoring
4 - Symptoms poorly controlled; history of re-hospitalizations

Note that in Column 2 the rating for symptom control of each
<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnoses (Sequencing of diagnoses should reflect the seriousness of each condition and support the disciplines and services provided.)</td>
<td>ICD-9-C M and symptom control rating for each condition. Note that the sequencing of these ratings may not match the sequencing of the diagnoses</td>
<td>Complete if a V-code is assigned under certain circumstances to Column 2 in place of a case mix diagnosis.</td>
<td>Complete only if the V-code in Column 2 is reported in place of a case mix diagnosis that is a multiple coding situation (e.g., a manifestation code).</td>
</tr>
<tr>
<td>Description</td>
<td>Description/ ICD-9-C M</td>
<td>Description/ ICD-9-C M</td>
<td>Description/ ICD-9-C M</td>
</tr>
<tr>
<td><strong>(M1020) Primary Diagnosis</strong></td>
<td><strong>(V-codes are allowed)</strong></td>
<td><strong>(V- or E-codes NOT allowed)</strong></td>
<td><strong>(V- or E-codes NOT allowed)</strong></td>
</tr>
<tr>
<td>a.</td>
<td>a. (___ ___ . ___ )</td>
<td>a. (___ ___ . ___ )</td>
<td>a. (___ ___ . ___ )</td>
</tr>
<tr>
<td>b.</td>
<td>b. (___ ___ ___ . ___ )</td>
<td>b. (___ ___ . ___ )</td>
<td>b. (___ ___ . ___ )</td>
</tr>
<tr>
<td>c.</td>
<td>c. (___ ___ ___ . ___ )</td>
<td>c. (___ ___ . ___ )</td>
<td>c. (___ ___ . ___ )</td>
</tr>
<tr>
<td>d.</td>
<td>d. (___ ___ ___ . ___ )</td>
<td>d. (___ ___ . ___ )</td>
<td>d. (___ ___ . ___ )</td>
</tr>
<tr>
<td>e.</td>
<td>e. (___ ___ ___ . ___ )</td>
<td>e. (___ ___ . ___ )</td>
<td>e. (___ ___ . ___ )</td>
</tr>
<tr>
<td>f.</td>
<td>f. (___ ___ ___ . ___ )</td>
<td>f. (___ ___ . ___ )</td>
<td>f. (___ ___ . ___ )</td>
</tr>
</tbody>
</table>
(M1034) Overall Status: Which description best fits the patient’s overall status? (Check one)

☐ 0 - The patient is stable with no heightened risk(s) for serious complications and death (beyond those typical of the patient's age).

☐ 1 - The patient is temporarily facing high health risk(s) but is likely to return to being stable without heightened risk(s) for serious complications and death (beyond those typical of the patient's age).

☐ 2 - The patient is likely to remain in fragile health and have ongoing high risk(s) of serious complications and death.

☐ 3 - The patient has serious progressive conditions that could lead to death within a year.

☐ UK - The patient’s situation is unknown or unclear.

LIVING ARRANGEMENTS

| Patient Living Situation: Which of the following best describes the patient's residential circumstance and availability of assistance? (Check one box only.) Living Arrangement | Availability of Assistance |
|---|---|---|---|---|---|
| | round the clock | Regular daytime | Regular nighttime | Occasional / short-term assistance | No assistance available |
| Patient lives alone | 01 | 02 | 03 | 04 | 05 |
| Patient lives with other person(s) in the home | 06 | 07 | 08 | 09 | 10 |
| Patient lives in congregate situation (e.g., assisted living) | 11 | 12 | 13 | 14 | ☐ 15 |
RESPIRATORY STATUS
(M1400) When is the patient dyspneic or noticeably Short of Breath?
☐ 0 - Patient is not short of breath
☐ 1 - When walking more than 20 feet, climbing stairs
☐ 2 - With moderate exertion (e.g., while dressing, using commode or bedpan, walking distances less than 20 feet)
☐ 3 - With minimal exertion (e.g., while eating, talking, or performing other ADLs) or with agitation
☐ 4 - At rest (during day or night)

(M1500) Symptoms in Heart Failure Patients: If patient has been diagnosed with heart failure, did the patient exhibit symptoms indicated by clinical heart failure guidelines (including dyspnea, orthopnea, edema, or weight gain) at any point since the previous OASIS assessment?
☐ 0 - No [ Go to M2004 at TRN; Go to M1600 at DC ]
☐ 1 - Yes
☐ 2 - Not assessed [Go to M2004 at TRN; Go to M1600 at DC ]
☐ NA - Patient does not have diagnosis of heart failure [Go to M2004 at TRN; Go to M1600 at DC ]

(M1510) Heart Failure Follow-up: If patient has been diagnosed with heart failure and has exhibited symptoms indicative of heart failure since the previous OASIS assessment, what action(s) has (have) been taken to respond? (Mark all that apply.)
☐ 0 - No action taken
☐ 1 - Patient’s physician (or other primary care practitioner) contacted the same day
☐ 2 - Patient advised to get emergency treatment (e.g., call 911 or go to emergency room)
☐ 3 - Implemented physician-ordered patient-specific established parameters for treatment
☐ 4 - Patient education or other clinical interventions
☐ 5 - Obtained change in care plan orders
(M1700) Cognitive Functioning: Patient's current (day of assessment) level of alertness, orientation, comprehension, concentration, and immediate memory for simple commands.

- □ 0 - Alert/oriented, able to focus and shift attention, comprehends and recalls task directions independently.
- □ 1 - Requires prompting (cuing, repetition, reminders) only under stressful or unfamiliar conditions.
- □ 2 - Requires assistance and some direction in specific situations (e.g., on all tasks involving shifting of attention), or consistently requires low stimulus environment due to distractibility.
- □ 3 - Requires considerable assistance in routine situations. Is not alert and oriented or is unable to shift attention and recall directions more than half the time.
- □ 4 - Totally dependent

(M1730) Depression Screening: Has the patient been screened for depression, using a standardized depression screening tool?

- □ 0 - No
- □ 1 - Yes, patient was screened using the PHQ-2© scale. (Instructions for this two-question tool: Ask patient: “Over the last two weeks, how often have you been bothered by any of the following problems”) Not at all 0 - 1 day

<table>
<thead>
<tr>
<th>Little interest or pleasure in doing things</th>
<th>Several days 2 - 6 days</th>
<th>More than half of the days 7 - 11 days</th>
<th>Nearly every day 12 - 14 days</th>
<th>N/A Unable to respond</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 0</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ na</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feeling down, depressed, or hopeless?</th>
<th>Several days 2 - 6 days</th>
<th>More than half of the days 7 - 11 days</th>
<th>Nearly every day 12 - 14 days</th>
<th>N/A Unable to respond</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 0</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ na</td>
</tr>
</tbody>
</table>
(M1860) **Ambulation/Locomotion:** Current ability to walk safely, once in a standing position, or use a wheelchair, once in a seated position, on a variety of surfaces.

- **0** - Able to independently walk on even and uneven surfaces and negotiate stairs with or without railings (i.e., needs no human assistance or assistive device).
- **1** - With the use of a one-handed device (e.g. cane, single crutch, hemi-walker), able to independently walk on even and uneven surfaces and negotiate stairs with or without railings.
- **2** - Requires use of a two-handed device (e.g., walker or crutches) to walk alone on a level surface and/or requires human supervision or assistance to negotiate stairs or steps or uneven surfaces.
- **3** - Able to walk only with the supervision or assistance of another person at all times.
- **4** - Chairfast, unable to ambulate but is able to wheel self independently.
- **5** - Chairfast, unable to ambulate and is unable to wheel self.
- **6** - Bedfast, unable to ambulate or be up in a chair.

(M2110) **How Often** does the patient receive **ADL or IADL assistance** from any caregiver(s) (other than home health agency staff)?

- **1** - At least daily
- **2** - Three or more times per week
- **3** - One to two times per week
- **4** - Received, but less often than weekly
- **5** - No assistance received
- **UK** - Unknown [Omit “UK” option on DC]
EMERGENT CARE

(M2300) Emergent Care: Since the last time OASIS data were collected, has the patient utilized a hospital emergency department (includes holding/observation)?

- 0 - No [ Go to M2400 ]
- 1 - Yes, used hospital emergency department WITHOUT hospital admission
- 2 - Yes, used hospital emergency department WITH hospital admission
- UK - Unknown [ Go to M2400 ]
(M2310) **Reason for Emergent Care:** For what reason(s) did the patient receive emergent care (with or without hospitalization)? *(Mark all that apply.)*

- [ ] 1 - Improper medication administration, medication side effects, toxicity, anaphylaxis
- [ ] 2 - Injury caused by fall
- [ ] 3 - Respiratory infection (e.g., pneumonia, bronchitis)
- [ ] 4 - Other respiratory problem
- [ ] 5 - Heart failure (e.g., fluid overload)
- [ ] 6 - Cardiac dysrhythmia (irregular heartbeat)
- [ ] 7 - Myocardial infarction or chest pain
- [ ] 8 - Other heart disease
- [ ] 9 - Stroke (CVA) or TIA
- [ ] 10 - Hypo/Hyperglycemia, diabetes out of control
- [ ] 11 - GI bleeding, obstruction, constipation, impaction
- [ ] 12 - Dehydration, malnutrition
- [ ] 13 - Urinary tract infection
- [ ] 14 - IV catheter-related infection or complication
- [ ] 15 - Wound infection or deterioration
- [ ] 16 - Uncontrolled pain
- [ ] 17 - Acute mental/behavioral health problem
- [ ] 18 - Deep vein thrombosis, pulmonary embolus
- [ ] 19 - Other than above reasons
  - [ ] UK - Reason unknown
APPENDIX H: SUMMARY FOR REASONS FOR HOSPITAL READMISSIONS
Table H-1  Summary for Reasons for Hospital Readmissions

<table>
<thead>
<tr>
<th>Reason for Emergent Care</th>
<th>Usual Care</th>
<th>Intervention</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percentage</td>
<td>Frequency</td>
</tr>
<tr>
<td>M2430</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2  Injury caused by fall</td>
<td>2</td>
<td>2.9</td>
<td>3</td>
</tr>
<tr>
<td>3  Respiratory infection (e.g., pneumonia, bronchitis)</td>
<td>3</td>
<td>4.3</td>
<td>3</td>
</tr>
<tr>
<td>4  Other respiratory problem</td>
<td>1</td>
<td>1.4</td>
<td>2</td>
</tr>
<tr>
<td>5  Heart failure (e.g., fluid overload)</td>
<td>9</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>6  Cardiac dysrhythmia (irregular heartbeat)</td>
<td>2</td>
<td>2.9</td>
<td>0</td>
</tr>
<tr>
<td>7  Myocardial infarction or chest pain</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>9  Stroke (CVA) or TIA</td>
<td>1</td>
<td>3.1</td>
<td>0</td>
</tr>
<tr>
<td>11 GI bleeding, obstruction, constipation, impaction</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>13 Urinary tract infection</td>
<td>2</td>
<td>2.9</td>
<td>0</td>
</tr>
<tr>
<td>16 Uncontrolled pain</td>
<td>1</td>
<td>1.4</td>
<td>0</td>
</tr>
<tr>
<td>17 Acute mental/behavioral health problem</td>
<td>1</td>
<td>1.4</td>
<td>0</td>
</tr>
<tr>
<td>19 Schedule treatment or procedure</td>
<td>2</td>
<td>2.9</td>
<td>1</td>
</tr>
<tr>
<td>20 Other than Above</td>
<td>8</td>
<td>11.6</td>
<td>16</td>
</tr>
</tbody>
</table>
Figure H-1. Summary of Reasons for Hospitalizations
<table>
<thead>
<tr>
<th>M2310</th>
<th>Description</th>
<th>Usual Care</th>
<th></th>
<th>Intervention</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Respiratory infection (e.g., pneumonia, bronchitis)</td>
<td>1</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>16.7</td>
</tr>
<tr>
<td>15</td>
<td>Wound infection or deterioration</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>50</td>
<td>1</td>
<td>16.7</td>
</tr>
<tr>
<td>19</td>
<td>Other than above reasons</td>
<td>1</td>
<td>25</td>
<td>1</td>
<td>50</td>
<td>2</td>
<td>33.3</td>
</tr>
<tr>
<td>99</td>
<td>Reason unknown</td>
<td>1</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>33.3</td>
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</tbody>
</table>
APPENDIX I: DESCRIPTIVE RESULTS OF INTENT TO TREAT FOR REMOTE MONITORING
### Descriptive Results for Intent to Treat of HF TIF

<table>
<thead>
<tr>
<th>Component</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Between-Component Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>118</td>
<td>0.14</td>
<td>0.344</td>
<td>0.07</td>
<td>0.2</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>8</td>
<td>0.25</td>
<td>0.463</td>
<td>-0.14</td>
<td>0.64</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>15</td>
<td>0.47</td>
<td>0.516</td>
<td>0.18</td>
<td>0.75</td>
<td>0</td>
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</tr>
<tr>
<td></td>
<td>4</td>
<td>67</td>
<td>0.09</td>
<td>0.288</td>
<td>0.02</td>
<td>0.16</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>210</td>
<td>0.15</td>
<td>0.356</td>
<td>0.1</td>
<td>0.2</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.346</td>
<td>0.024</td>
<td>0.1</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Fixed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.074</td>
<td>-0.06</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX J: COST OUTCOMES OF USUAL CARE
<table>
<thead>
<tr>
<th>Cost of Usual Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings due to skilled nursing utilizations</td>
</tr>
<tr>
<td>Number of visits per patient</td>
</tr>
<tr>
<td>Direct benefits SN</td>
</tr>
<tr>
<td>Net HHRG Score</td>
</tr>
<tr>
<td>Net program costs</td>
</tr>
<tr>
<td><strong>Profit:</strong></td>
</tr>
</tbody>
</table>
APPENDIX K: COST OUTCOMES OF REMOTE MONITORING
## Cost of Remote Monitoring

<table>
<thead>
<tr>
<th>Savings due to skilled nursing utilizations</th>
<th>Average cost per visit</th>
<th>$40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of visits per patient</td>
<td>17.06</td>
<td></td>
</tr>
<tr>
<td>Direct benefits SN</td>
<td>$40 * 17.06</td>
<td></td>
</tr>
<tr>
<td>Net HHRG Score</td>
<td>$2,624.12</td>
<td></td>
</tr>
<tr>
<td>Net program costs + TM cost per patient</td>
<td>($40*17.06) - $2624.12</td>
<td></td>
</tr>
</tbody>
</table>

**Profit:** 1,641.85
APPENDIX L OPERATIONALIZATION OF STUDY VARIABLES FOR THE INTERACTION EFFECT OF STRUCTURE AND PROCESS ON OUTCOMES
Operationalization of Study Variables Interaction Effect of Structure and Process on Outcomes

<table>
<thead>
<tr>
<th>Exogenous</th>
<th>Covariate</th>
<th>Defined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intent_1</td>
<td>0 = 0% to 49% , 3 = 51% to 75% , 4 = 76% to 100% completion of remote monitoring</td>
<td></td>
</tr>
<tr>
<td>Process</td>
<td>0 - No action taken (1510-0); 1 - MD contacted the same day (1510-1); 2 - Patient advised to get emergency treatment (1510-2); 3 - Implemented physician-ordered patient-specific established parameters for treatment (1510-3); 4 - Patient education or other clinical interventions (1510-4); 5 - Obtained change in care plan orders (1510-5).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Endogenous</th>
<th>Cost Outcomes</th>
<th>Defined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Visits</td>
<td>Total skilled nursing visits for one episode of care per patient</td>
<td></td>
</tr>
<tr>
<td>NetHHRG1 episodeofcare</td>
<td>Net income in one episode of care per patient</td>
<td></td>
</tr>
<tr>
<td>Agency Cost</td>
<td>Total Visits minus Net HHRG per patient</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Endogenous</th>
<th>Health Outcomes</th>
<th>Defined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total RA</td>
<td>Hospital Readmissions per patient</td>
<td></td>
</tr>
<tr>
<td>Total ER</td>
<td>Emergency department visits without hospital readmission</td>
<td></td>
</tr>
<tr>
<td>1400DCdyspnea</td>
<td>clinical status at discharge: 0 - No shortness of breath, 1 - walking more 20 feet, 2 moderate exertion, 3 - minimal exertion; 4 - at rest</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX M: INSTITUTIONAL REVIEW BOARD APPROVAL
Approval of Exempt Human Research

From: UCF Institutional Review Board #1  
FWA0000351, IRB00001138

To: Cynthia Williams

Date: October 14, 2013

Dear Researcher:

On 10/14/2013, the IRB approved the following activity as human participant research that is exempt from regulation:

- Type of Review: Exempt Determination
- Project Title: Home Health Quality of Remoting Monitoring
- Investigator: Cynthia Williams
- IRB Number: SBE-13-09625
- Funding Agency: 
- Grant Title: 
- Research ID: NA

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iIRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 10/14/2013 03:06:14 PM EDT

IRB Coordinator
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