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A Propensity-Matched, Mortality-Adjusted Study of Palliative Care Consult to Reduce 90-day Hospital Readmission in a Heart Failure Cohort

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We hereby certify that this dissertation, submitted by Janice Shirley conforms to acceptable standards and is fully adequate in scope and quality to fulfill the dissertation requirement for the degree of Doctor of Philosophy in Health Science.

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Abstract

The Centers for Medicare and Medicaid Services (CMS) instituted the Hospital Readmission Reduction Program (HRRP) to reduce the frequency of heart failure (HF) 30-day hospital readmissions. To meet the needs of patients with end-stage HF, palliative care (PC) is promoted to provide additional support to patients and reduce unnecessary hospital readmission. While PC is a plausible and logical intervention, effectiveness in achieving a reduction in readmissions has not been assessed in an HF population with adequate controls to assess confounding. The goal of this research was to assess the effectiveness of palliative care for HF (HFPC) consult to effect change in 90-day hospital readmissions in a propensity-matched model that adequately controls for mortality at a single-site 526-bed tertiary-care facility. Index hospitalization for live HF discharges: Oct 1 - Dec. 31, 2019, n =250. Propensity matching aided in achieving a more homogeneous population with less variability and ensured a greater likelihood of observing an accurate and valid assessment of the outcome of interest. Results were statistically significant, demonstrating a strong association between HFPC consult and 90-day hospital readmission in a propensity-matched population. Logistic regression showed a statistically significant association between HFPC and 90-day hospital readmission, $p < .001$. The logit transformation of the HFPC factor, *OR* 4.3, 95% CI [1.8 - 10.6]. Survival analysis demonstrated that time to readmission happens more frequently in patients who have an HFPC consult; readmissions occur earlier in the post-discharge period and are strongly skewed to the immediate 30-day post-discharge period. Further, more than 50% of HF patients who have an HFPC consult experience a hospital readmission within 30 days of discharge, and more than 75% of HF patients who have an HFPC consult will have a hospital readmission within 90 days of discharge. This dissertation study demonstrated that while HFPC may be an important aspect of continuity of care and care

planning for HF patients, it has a strong negative association with the objective of reducing hospital readmissions. HFPC consult predicted earlier hospital readmissions in this HF population with high morbidity, approaching end-of-life.

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List of Abbreviations

AMI	Acute myocardial infarction
ACA	Affordable Care Act
ACE	Angiotensin Converting Enzyme inhibitors
AMA	Against Medical Advice
ARB	Angiotensin Receptor Blocker
CABG	Coronary artery bypass graft surgery
CMS	Centers for Medicare and Medicaid Services
COPD	Chronic Obstructive Pulmonary Disease
CRT	Cardiac Resynchronization Therapy device
EF%	Ejection Fraction Percent
HF	Heart Failure
HFPC	Heart Failure Palliative Care
HRR	Hospital readmission rates
HRRP	Hospital Readmission Reduction Program
IABP	Intra-Aortic Balloon Pump
ICD	Implantable Cardiac Defibrillator
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th revision
PC	Palliative Care
PMHx	Past Medical History
SNF	Skilled Nursing Facility
SPSS	Statistical Package for the Social Sciences

Chapter 1: Introduction

Introduction

The Centers for Medicare and Medicaid Services (CMS) instituted the Hospital Readmission Reduction Program (HRRP) to reduce the frequency of heart failure (HF) 30-day hospital readmissions. To fill the health care needs of patients with end-stage heart failure, palliative care (HFPC) and hospice referrals are promoted to provide additional support to patients, in addition to their primary care and specialist physicians, and reduce unnecessary hospital readmission. While HFPC is a plausible and logical intervention, effectiveness in achieving a reduction in readmissions has not been assessed in a heart failure population with adequate controls to assess potential sources of confounding and interaction. This dissertation study demonstrated the error of this assumption.

Patients must have a diagnosis of end-stage heart failure to be eligible for referral to palliative care (PC). Patients with end-stage heart failure are intuitively expected to have a higher rate of mortality compared to patients without a diagnosis of end-stage heart failure. These factors suggest that patients eligible for HFPC would be at higher risk for increased mortality events than patients not eligible for HFPC services; thus, any evidence supporting HFPC as an intervention to reduce hospital readmission should control mortality. However, most administrative datasets used for health services research do not capture mortality.

Currently, hospital-readmission metrics include all patients diagnosed with HF who are readmitted within a 30-day time period in their numerator, with the denominator including all patients discharged with a diagnosis of HF. If the patient experiences a mortality event in the 30-day period after hospital discharge, there is no opportunity for readmission, and the mortality event does not accrue to the numerator of the admitting hospital readmission metric. Studies, to

date, have evaluated the efficacy of palliative care to achieve a reduction in hospital readmissions but have not evaluated this potential for significant differential mortality. Thus, not accounting for mortality in follow-up studies evaluating the effectiveness of HFPC (Palliative Care for Heart Failure) may result in significant ascertainment bias. If differential mortality is present but unquantified and mortality is more prevalent in the HFPC group, a Type I error will occur, or a significant intervention effect will be found when, in truth, there is no intervention effect.

This investigation evaluated the potential for differential mortality in the relationship between 90-day HF hospital readmission and eligibility for referral to HFPC with a thorough mortality follow-up of all patients admitted for HF. This investigation assessed the mortality-adjusted, propensity-matched (severity-adjusted) relationship between HFPC consult and 90-day hospital readmission in patients with a diagnosis of end-stage heart failure (HF) in the current context of administrative mandates that aim to reduce the frequency of HF hospital readmissions.

Problem Statement

Heart failure is the most common discharge diagnosis in the United States, affecting 5.1 million people annually (Arora et al., 2017; Fasolino & Phillips, 2016). Of the estimated 900,000 COVID-19 hospitalizations that occurred through November 2020, 12% of hospitalizations were attributable to heart failure (O'Hearn et al., 2021). The Centers for Medicare and Medicaid Services (CMS) implemented components of the 2010 Affordable Care Act with the introduction of the Hospital Readmission Reduction Program (HRRP) and publicly reported hospital 30-day all-cause risk-standardized mortality rates and 30-day all-cause risk-standardized readmission rates for acute myocardial infarction (AMI), heart failure (HF), and pneumonia (Krumholz et al., 2013). In October 2012, CMS introduced penalties and reduced Medicare payments for excess

readmissions in a broad array of inpatient hospitalizations, specifically HF, based on a ratio of predicted versus expected 30-day readmissions (Medicare, 2017). According to Davis et al. (2017), a higher than expected rate of 30-day readmissions following HF hospitalization can negatively impact hospital performance measures and incur reimbursement penalties. A myriad of interventions has since been proposed to decrease the number of HF readmissions (Bradley et al., 2013). The introduction of palliative care to end-stage organ failure patients is new and has received increasing attention worldwide in the last decade (Ng et al., 2016).

Research evaluating the effectiveness of a PC consult in the setting of acute hospitalization for HF as an intervention to decrease 30-day hospital readmission has shown mixed results and methodological limitations. A broad array of guidelines promote its adoption, while the literature has demonstrated poor reproducibility of the reliability of an HFPC consult to effectively reduce hospital readmissions (Chuang & Fausto, 2014; Chuang et al., 2017; Nelson et al., 2011; O'Connor et al., 2015; Wiskar et al., 2017). Retrospective studies have been limited by a lack of validation studies assessing sensitivity and specificity of the PC consultation coding (ICD9-V66.7) and ascertainment bias with an inability to measure differential mortality (Hua et al., 2017; Wiskar et al., 2017). Prospective studies have been limited by low enrollment and loss to follow-up, leading to the study being underpowered, with unintended crossover and limited PC staffing resources to sustain the intervention (Sidebottom et al., 2015; Szekendi et al., 2016). The goal of this dissertation study was to assess the effectiveness of HFPC consult to effect change in 90-day hospital readmissions in a propensity-matched model that adequately controls for mortality at a single-site 526-bed tertiary-care facility.

Heart Failure

The impetus for HFPC arises from issues pertaining to the incidence, prevalence, and cost of HF, which is the most common discharge diagnosis in the United States, affecting more

than five million patients annually (Arora et al., 2017; Fasolino & Phillips, 2016). By 2030, with prevalence remaining stable, more than eight million patients in the United States will have HF, with expected three-year mortality rates as high as 50% among Medicare beneficiaries after an HF admission (Heidenreich et al., 2013). Even if prevalence remains constant for age, sex, race, or ethnicity, rising costs and technological innovation are expected to increase the total direct medical costs of HF from $21 billion to $53 billion. Inclusive of indirect costs, total expenditure is projected to increase from $31 billion to $70 billion in 2030 (Heidenreich et al., 2013).

Readmissions

The impetus for HFPC arises out of issues relating to hospital readmission rates. Readmission rates were first introduced in 1953 to characterize risk among neuropsychiatric patients discharged from the Department of Veterans Affairs (VA) hospitals (Jenkins et al., 1953). In 2009, CMS began to publicly report hospital 30-day all-cause risk-standardized mortality rates and 30-day all-cause risk-standardized readmission rates for AMI, HF, and pneumonia (Centers for Medicare and Medicaid Services, 2015; Krumholz et al., 2013). The 2010 Affordable Care Act implemented the HRRP on the premise that a hospital's scope of responsibility should include post-discharge care coordination (Centers for Medicare and Medicaid Services; Chin et al., 2016).

In October 2012, CMS began reducing Medicare payments for inpatient hospitalizations based on a ratio of predicted versus expected 30-day readmissions for AMI, HF, pneumonia, Chronic Obstructive Pulmonary Disease (COPD), hip or knee replacement, and CABG surgery (Centers for Medicare and Medicaid Services, 2015). More than the expected 30-day readmissions following HF hospitalization negatively impacts hospital performance measures and reimbursement (Davis et al., 2017). A myriad of interventions have since been proposed to decrease the number of HF readmissions, some criticized as encouraging inappropriate care

strategies to achieve a reduction in readmission rates (Bradley et al., 2013; Woolhandler & Himmelstein, 2016). However, whether HFPC is an appropriate care strategy to achieve these aims has not been fully evaluated.

CMS implemented thirty-day readmission rates despite limited evidence supporting 30-day readmission rates as an indicator of between-hospital variation in the quality of care (Chin et al., 2016; National Quality Forum, 2016). The team that developed the metrics noted low intracluster correlation coefficients (ICC) of 4.8-5.3% for mortality measures and 1.5-2.6% for readmission measures (Chin et al., 2016). ICCs represent the proportion of risk explained by hospitals (between-hospital variation) compared to the total risk in the population (all variation; Chin et al., 2016). This poor correlation was further evaluated by Chin et al. (2016), who found a sharp and consistent reduction in the readmission ICC after the seventh-day post-discharge, suggesting that a significant proportion of the presumed hospital quality signal at 30 days may be attributed to other characteristics of the individual and community setting of care. These characteristics include the socioeconomic and demographic profile of the hospital's patient population, the hospital's resource availability, and patient social support or mental health issues (Chin et al., 2016; Pandey et al., 2017).

Other HF studies have likewise failed to demonstrate a strong association between in-hospital quality of care and 30-day readmission rates (Fischer et al., 2015). The goal of the selection of 30-day readmission rates as an indicator of quality relates more to encouraging hospitals to assume responsibility for post-discharge adherence and primary care follow-up rather than hospital quality of care. In addition, it is to represent a public policy intended to shift responsibility to the hospital provider to promote a more cohesive shared responsibility for

continuity of care (Chin et al., 2016). Time to readmission intervals was an important consideration for this investigation and the determination of HFPC effectiveness.

Hospitals with the greatest burden of readmissions are more likely to be penalized for higher readmission rates, raising questions of whether CMS readmissions penalties are equitably and justly applied for hospitals with a high prevalence of socially or medically complex patients (Pandey et al., 2017). A recent evaluation of readmissions for AMI, a condition related to HF, found an inequitable burden of readmission among hospitals serving patient populations with higher levels of social disadvantage and higher illness acuity (Pandey et al., 2017). Inequity is an important consideration in the evaluation of HFPC, which is also prone to similar inequities. AdventHealth Tampa was chosen as the site for this investigation primarily because of its advocacy of PC services to the HF population.

Studies have established a temporal decline in HF readmissions but have been criticized as confounded by changes in coding rather than improvements in care (Desai et al., 2016; Jha, 2015; Zuckerman et al., 2016). Emerging evidence has also demonstrated the potentially harmful effects of the HRRP with increased mortality associated with continuing implementation (Dharmarajan et al., 2017; Fonarow et al., 2017; Gupta et al., 2017; Krumholz et al., 2013). There are emerging calls for HRRP outcome metrics to be reevaluated to align with evidence that acute care and discharge quality metrics do not appear to influence readmissions. Hospital readmissions are often attributable to individual and community aspects of care, indicating the need to identify better quantified strategies that can reliably meet patients' needs and effectively manage morbidity, leading to unnecessary hospital readmission. Alternative explanations of decreasing HF readmission trends are an important consideration of efficacy in evaluating HFPC and its relationship to reducing 90-day hospital readmissions. This dissertation study also

assessed the differential time to readmission for patients who have an HFPC consult compared to those who do not. The study will contribute to the evidence on the effectiveness of palliative care to meet these diverse patient needs and reduce hospital readmission. Specifically, this research assessed the effectiveness of palliative care for HF (HFPC) consult to effect change in 90-day hospital readmissions in a propensity-matched model that adequately controls for mortality.

Palliative Care

The expansion of palliative care programs beyond cancer to end-stage organ failure patients is new and has received increasing widespread attention worldwide in the last decade (Ng et al., 2016). A key element of hospital interest in palliative care is the risk adjustment it affords, the presence of a coded palliative care consult (V667) or hospice referral on the electronic medical record of the patient admitted with HF increases the expected count of HF readmissions in CMS quality calculations and creates a greater opportunity for the hospital to have a less than the expected count of HF readmissions, which translates into a higher quality score for the admitting hospital (Trivette, 2017).

PC has shown an ability to reduce readmission rates in mixed patient populations (Nelson et al., 2011; O'Connor et al., 2015). Preceding implementation of HRRP, Kaiser Permanente researchers conducted a prospective pre versus post-intervention with a fully constituted PC team. They found a statistically significant[2] reduction in six-month readmissions from 1.15 to 0.7 readmissions per patient (Nelson et al., 2011). After implementing HRRP, University of Pennsylvania researchers conducted a retrospective review of PC consults and reported a protective effect[3] for 30-day hospital readmission (O'Connor et al., 2015). Both studies were limited by a study population that relied on the presence of a PC consult request, creating a

[2] $p = .025$

[3] OR 0.66, $p < 0.001$, 95% CI [0.55 - 0.78]

significant risk of selection bias, in that patients most likely to adhere to PC guidance were selected and therefore likely to bias the observed results.

Furthermore, mortality was not assessed; this added an ascertainment bias. Ascertainment bias and the significant potential for confounding by mortality were important elements controlled for in this investigation in establishing the effectiveness of HFPC to reduce 90-day hospital readmissions. A broad array of stakeholders have also produced consensus statements that support the introduction of palliative care for HF (American Academy of Hospice Palliative Medicine, Center to Advance Palliative Care, Hospice Palliative Nurses Association, Last Acts Partnership & National Hospice Palliative Care Organization, 2004; Davies & Higginson, 2004; Goodlin et al., 2004; Jaarsma et al., 2009; Yancy et al., 2013). These guidelines also identify several challenges, including defining criteria for appropriateness for HFPC consultation, barriers to referral, consistency of service delivery, and HFPC team resources.

Another factor that influences the consistent adoption of palliative care in the acute care environment is the broad variability in the hospital-level perceived appropriateness for an HFPC consult. Even though overall eligibility for an HFPC consult is consistently high, with 18.8% of the total inpatient population determined to be eligible, HFPC consult rates for eligible patients varied widely from 12.5% - 58.8%, but not achieving 100% referral of eligible patients (Szekendi et al., 2016). Evaluating variation in appropriateness by diagnosis, Szekendi et al. (2016) found that patients with poor prognosis cancer were appropriate for a PC consult 100% of the time, while patients with advanced HF (Class IV, LVAD, or EF <35%) were appropriate just 33% of the time. Demonstrating similar challenges to appropriately identify patients for a PC consult in the setting of a complex chronic condition, patients with a diagnosis of COPD (oxygen-dependent or FEV1 <30%) received an appropriate referral just 32% of the time. This

variation in appropriateness for PC consultation by diagnostic criteria demonstrates the confusion of non-PC clinicians who are primarily familiar with the system of palliative care that focuses on cancer end-of-life care. The hospital site for this investigation was specifically chosen because it has been a consistent, strong proponent of PC services to the HF population.

Another important factor is the consistency of delivery of PC services. Of those appropriate for referral, a minority (31.6%) received a referral and actual delivery of any PC services (Szekendi et al., 2016). A further 29.8% received a referral but no PC services, and the remaining 60.9% of those appropriate for a referral received neither a referral nor services (Szekendi et al., 2016). A physician order is often necessary to operationalize PC or hospice referral but is not sufficient to ensure completed service delivery. AdventHealth Tampa has eliminated this barrier by implementing a site policy enabling activation of a nurse-initiated HFPC consult request. There is also considerable variation in the definition of what services are included in a palliative care consult for HF (Szekendi et al., 2016). Other work has suggested that HFPC focused primarily on symptom control did not decrease readmissions[4] compared to HFPC focused on advanced care planning and goals[5] (O'Connor et al., 2015). Poor consistency of service delivery complicates the ability of the non-PC clinician to be confident in the services that may be provided if an HFPC consult is requested and likewise for researchers determining effectiveness (Szekendi et al., 2016). The consistency of service delivery at AdventHealth Tampa via a site policy enabling nurse-activated HFPC consult requests minimizes the potential bias of this issue. The resources available on the HFPC team are also variable and may include a PC physician, an inpatient PC RN, a social worker, a bioethicist, and hospital chaplain;

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[4] *OR* 1.05, p =0.684, 95% CI [0.82 - 1.35]

[5] *OR* 0.36, $p < 0.001$, 95% CI [0.27 - 0.48]

alternatively, it may comprise a palliative care RN only, or there may be no team available (Nelson et al., 2011).

Lastly, validating completed service delivery is complicated by variable hospital coding practices, defined as documentation of an ICD-9 V66.7 palliative care encounter, ranging from 0-100%, limiting the accuracy and reliability of administrative data (Szekendi et al., 2016). This evidence demonstrates important methodological issues: (a) consistency of referral to PC services, (b) consistency of availability of PC services, (c) reliability of completed service delivery, (d) consistency and reproducibility of PC services provided, and (e) reliability of accurately assessing the delivery of PC services. AdventHealth Tampa minimizes these methodological issues respectively by (a) enabling nurse-activated HFPC consult requests, (b) partnerships that ensure consistency of availability of PC services, (c) reliability of completed consult on the medical record, (d) consistency and reproducibility of PC services provided, albeit limited to this single site which may not be generalizable to the broader population of hospitals, and (e) reliability of the completed consult is verifiable within the body of the medical record. While the reliability of the model of services for HFPC is an important aspect of HFPC service delivery, the scope of services provided is beyond the scope of this investigation.

A third factor is the reliability of the model of services for HFPC that is significantly different from cancer-focused end-of-life care compared to an end-organ failure trajectory of decline (Jaarsma et al., 2009). The trajectory of decline associated with end-organ dysfunction, such as HF, demonstrates a more gradual loss of function interrupted by acute exacerbations that cause sudden precipitous losses in function without a full return to baseline over time; this indicates a need to reevaluate the underlying assumptions that have been developed from a primarily cancer-focused end of life care model and applied to HF management to decrease

readmissions (Jaarsma et al., 2009). The scope of services provided for cancer-focused PC would be expected to be substantively different than the scope of services for HFPC. In addition, PC efficacy based on previously mixed patient populations cannot be reliably generalized to the population of patients with HF demonstrating different trajectories of decline. While the model of services for HFPC is important, it is beyond the defined scope of this investigation.

A fourth factor is the major barriers that exist in initiating a physician-ordered referral for palliative care: (a) there is typically no standard definition of palliative care within the organization, resulting in subjective criteria and wide variation amongst clinicians; (b) HFPC is erroneously associated with end of life care and life expectancy of two weeks or less; (c) educational opportunities for non-PC clinicians to gain skills in primary palliative care are infrequent and rarely mandatory; (d) subspecialist physicians with longstanding patient relationships retain a desire to maintain that relationship and provide subspecialist management that may not be met by a HFPC clinician; and (e) an internal psychological conflict that exists for both patients and clinicians in the perception of referral to HFPC indicates a choice for end of life care and the seemingly competing interest to seek advanced specialty care and pursue access to advanced cutting edge therapies, for example, “giving up” versus “doing everything” (Szekendi et al., 2016). While these human factors issues are important, they are beyond the scope of this investigation.

Despite these challenges, several recent studies have sought to establish the effectiveness of HFPC to reduce hospital readmission. A large post-HRRP longitudinal analysis using the Agency for Healthcare Quality and Research (AHRQ) Nationwide Readmission Database (NRD) that compiles all hospital admissions for patients from 22 states and tracks patients throughout the year found that propensity-matched HF patients with a primary diagnosis of HF (ICD9

428.xx) who received an HFPC consult were 58% less likely to be readmitted for HF,[6] and 54% were less likely to be readmitted for any cause[7] during the nine-month follow-up period (Wiskar et al., 2017). Noting the inherent susceptibility of administrative datasets to diagnostic and procedure coding errors, the authors noted a limitation for this study was the absence of validation in an HF population that coding of a PC visit actually occurred and relied on previous validation of PC coding in a stroke population with a sensitivity of 81% and specificity of 97% (Wiskar et al., 2017). A second validation study in a mixed patient population at a single center noted problems assessing the validity of the V66.7 code for documentation of PC consultation with a poor sensitivity of 53.9% and specificity of 75.1% (Hua et al., 2017).

Montefiore Medical Center researchers further evaluated the effectiveness of HFPC with a retrospective cohort study and, in a reversal of their findings from an earlier 2014 study, found that while fewer patients with a completed palliative care consult were readmitted, compared to those with a consult ordered but not completed, the difference was not statistically significant[8] (Chuang & Fausto, 2014; Chuang et al., 2017). The researchers noted an important limitation in their studies was an inability to control for mortality that may produce a differential assessment of the readmission outcome; patients with HFPC consultation or hospice referral may die, resulting in fewer readmissions in the HFPC cohort. Allina Health investigators executed a randomized intervention for patients appropriate for HFPC but noted no statistically significant change in readmission within 30 days[9] (Sidebottom et al., 2015). Interpretation of results was limited by an underpowered sample size, crossover, and losses to follow-up if readmission occurred outside of the hospital system (Sidebottom et al., 2015). While not reflective of a US

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[6] 9.3% versus 22.4%, $p < 0.01$
[7] 29.0% versus 63.2%, $p < 0.01$
[8] 43% and 53%, respectively, $x2 = 1.9$, $p = 0.171$
[9] *HR* 1.43, 95% CI [0.5 - 4.1]

health care system or population, the challenge of reducing HF readmissions with HFPC has also been evaluated in international settings in Hong Kong with a randomized intervention that noted the absence of a statistically significant difference[10] (Wong et al., 2016). These studies reflect the limitations found in previous studies that showed important confounders that were controlled for in this investigation of HFPC and its effectiveness at decreasing 90-day hospital readmission.

Relevance and Significance

This dissertation study is relevant to the development of evidence in several key health care areas of interest, including heart failure, hospital readmissions, and palliative care. Heart failure prevalence is increasing; administrative pressures to reduce hospital readmissions show no sign of weakening, and alternative strategies like palliative care require an evidence-based and methodologically rigorous evaluation of outcomes. This study assessed whether a hospital-generated referral to palliative care services could reduce 90-day hospital readmissions for heart failure in a propensity-matched model after controlling for mortality.

Research Question and Hypotheses

This dissertation study addressed the following research questions and hypotheses:

RQ1: Will a hospital-generated referral to palliative care services reduce 90-day hospital readmissions for heart failure in a propensity-matched model after controlling for mortality?

H0: There is no significant difference in 90-day readmissions in HF patients receiving HFPC consultation versus patients not receiving HFPC consultation after controlling for mortality and severity.

H1: The increased level of resources, education, facilitated decision-making, and future health planning would enable patients to better understand their symptoms and improve health

[10] 20.9% versus control 29.3%, $x2 = 4.41$, $p = 0.79$

behaviors through a better understanding of the health system that will allow them to seek health care services in less hospital-oriented settings and ultimately decrease hospital readmissions.

H1a: There is a statistically significant difference in 90-day readmissions in HF patients receiving HFPC consultation versus patients not receiving HFPC consultation after controlling for mortality and severity.

To answer the research question, appropriate measures were abstracted to assess the impact of previously unaddressed confounders that carry a significant risk of ascertainment bias (e.g., mortality). The research question also ensured the comparison of similar risk characteristics by using a propensity-matched model (e.g., comparing hospital readmissions of patients with HF with similar acuity). This investigator assumes that a better understanding of the health system will enable patients to seek health care services in less hospital-oriented settings and ultimately decrease hospital readmissions.

Definition of Terms

AMI	Acute myocardial infarction
ACA	Affordable Care Act
ACE	Angiotensin Converting Enzyme inhibitors
AMA	Against Medical Advice
ARB	Angiotensin Receptor Blocker
CABG	Coronary artery bypass graft surgery
CMS	Centers for Medicare and Medicaid Services
COPD	Chronic Obstructive Pulmonary Disease
CRT	Cardiac Resynchronization Therapy device
EF%	Ejection Fraction Percent

HF	Heart Failure
HFPC	Heart Failure Palliative Care
HRR	Hospital readmission rates
HRRP	Hospital Readmission Reduction Program
IABP	Intra-Aortic Balloon Pump
ICD	Implantable Cardiac Defibrillator
ICD-10	International Statistical Classification of Diseases and Related Health Problems, 10th revision
PC	Palliative Care
PMHx	Past Medical History
SNF	Skilled Nursing Facility
SPSS	Statistical Package for the Social Sciences

Summary

Recent administrative mandates from the Centers for Medicare and Medicaid Services embodied in the Hospital Readmission Reduction Program aim to reduce the frequency of heart failure 30-day hospital readmissions. To fill the health care needs of patients with end-stage heart failure, palliative care referrals are promoted to provide additional support to patients in addition to their primary care and specialist physicians. As a result, patients have an improved understanding of their disease, improving disease management and thereby decreasing hospital utilization, thus reducing hospital 30-day readmissions after an index HF hospitalization.

Heart failure is the most common discharge diagnosis in the United States, affecting 5.1 million annually (Arora et al., 2017; Fasolino & Phillips, 2016). CMS implemented components of the 2010 Affordable Care Act with the introduction of the HRRP and initiated public reporting

of key hospital metrics for mortality and readmission rates for AMI, HF, and pneumonia (Krumholz et al., 2013). In October 2012, penalties were introduced, and Medicare payments for inpatient hospitalizations were reduced based on a ratio of predicted versus expected 30-day readmissions (Medicare, 2017). HFPC for end-stage organ failure patients is widely promoted as an effective intervention and has received increasing attention worldwide in the last decade (Ng et al., 2016). As noted, research evaluating the effectiveness of HFPC consultation or hospice referral in the setting of acute hospitalization for HF as an intervention to decrease 30-day hospital readmission has yielded mixed results and methodological limitations (Chuang & Fausto, 2014; Chuang et al., 2017; Hua et al., 2017; Nelson et al., 2011; O'Connor et al., 2015; Sidebottom et al., 2015; Szekendi et al., 2016; Wiskar et al., 2017).

The hypothesis of this investigation was that the increased level of resources, education, facilitated decision-making, and future health planning would enable patients to better understand their symptoms and improve health behaviors through a better understanding of the health system that will allow them to seek health care services in less hospital-oriented settings and ultimately decrease hospital readmissions. This investigation assessed the effectiveness of palliative care referral to reduce 90-day hospital readmissions for heart failure. The research question measured the impact of potentially important mortality confounding, and it used a propensity-matched model to ensure comparison of similar risk characteristics. This research also assessed the mortality-adjusted relationship between HF propensity-matched cohorts and 90-day hospital readmission in the current context of administrative mandates that aim to reduce the frequency of HF hospital readmissions.

Chapter 2: Review of the Literature

Historical Review of the Literature Contributing to the Topic

A comprehensive historical review of the literature pertaining to this investigation of HFPC and 90-day hospital readmission requires an in-depth understanding of the literature associated with heart failure, hospital readmissions, and palliative care. It also requires an understanding of the factors that contribute to the societal and individual burden of heart failure, including (a) an assessment of the literature pertaining to the incidence, prevalence, pathogenesis, and disease progression of heart failure, (b) a review of the development and evolution of the hospital readmission metric and associated administrative mandates, (c) an understanding of the symptomatic burden of disease for patients. Moreover, a complete historical review of the literature for this investigation requires an understanding of the factors that contribute to the issues pertaining to HF readmissions, including (a) an appreciation of the economic burden for hospitals related to HF hospital readmission, (b) a recognition of the posited emergence of increased mortality associated with downward trends of HF readmission subsequent to initiation of the administrative mandates, (c) the challenges involved with identifying effective alternative strategies to reduce HF readmissions, and (d) an understanding of the complexities of medical management when implementing a comprehensive strategy to reduce HF readmission. Lastly, a full review of the literature pertaining to this investigation requires an understanding of the definition and evolution of palliative care, including (a) the variation in the trajectory of disease that requires careful consideration when applying a service traditionally developed to provide care for terminal cancer patients, (b) the breadth of recommendations and position statements that advocate for the use of palliative care in patients with HF, and (c) trends and barriers for implementation of HFPC consistently and reliably.

Historical Review of the Literature Relating to HF

A comprehensive historical review of the literature pertaining to the investigation of HFPC and 90-day hospital readmission requires an understanding of the factors that contribute to the societal and individual burden of heart failure, including (a) an assessment of the literature pertaining to the incidence, prevalence, pathogenesis and disease progression of heart failure, (b) a review of the development and evolution of the hospital readmission metric and associated administrative mandates, and (c) an understanding of the symptomatic burden of disease for patients. The sustained incidence, increasing prevalence, and significant lifetime risk create the strong imperative to improve all aspects of care associated with the diagnosis of HF. The prevalence of risk factors in the US population, the increasing prevalence of obesity and diabetes, the associated cost for care, and potentially significant increases in the future cost of care for patients with HF indicate a significant imperative to improve the care and management of individuals with HF. The challenges of a clinical syndrome with high mortality, complex medical management of multiple comorbidities, and challenges with identifying interventions with associated mortality benefit create the imperative for identifying new strategies for improved management of patients with HF.

Diagnosis and Case Definition of HF

HF is a complex clinical syndrome comprised of cardiac and pulmonary signs and symptoms, including paroxysmal nocturnal dyspnea, orthopnea, neck vein distension, rales, cardiomegaly, jugular venous pressure elevation, ankle edema, dyspnea on exertion, and pleural effusion (Dunlay & Roger, 2014).

Incidence and Prevalence of HF

The current incidence of HF is based on data from 2005 to 2014 from the National Heart, Lung, and Blood Institute's (NHLBI) Atherosclerosis Risk in Communities (ARIC) study's

community surveillance and demonstrates 1,000,000 incident cases annually in individuals ≥ 55 years of age (Huffman et al., 2013). Incident cases are also highly skewed towards older adults, with rates for White males per 1,000 person-years estimated at 32 cases over the age of 75, 11 for ages 65 -74, and 3.9 for ages 55-64 (Benjamin et al., 2018). Temporal trends in incidence suggested an overall decline in HF incidence between 2000 and 2010, while earlier studies indicated that the incidence of HF has remained largely stable over time (Barker et al., 2006; Gerber et al., 2015; Levy et al., 2002; McCullough et al., 2002).

In 2018, 6.5 million (2.5%) Americans ≥20 years of age were estimated to have a diagnosis of HF based on 2011 to 2014 National Health and Nutrition Examination Survey (NHANES) data, representing a 12% increase in prevalence from 2012, and consistent with the model projecting a prevalence of 8.5 million (3%) of Americans by 2030 (Benjamin et al., 2018; Heidenreich et al., 2013). Projections estimate a 46% increase in the prevalence of HF from 2012 to 2030 due to the aging of the population and improvements in the delivery of care that improve survival (Benjamin et al., 2018; Heidenreich et al., 2013). Prevalence is highly skewed towards older adults, with 14.1% of men over the age of 80, 6.2% of men 60-79, 1.4% of men age 40-59, and just 3% of men age 20-39 identified as cases. Prevalence data is based on self-report, calculated based upon a response of "yes" to the question of ever having congestive heart failure during the NHANES data collection (Benjamin et al., 2018). NHANES data are likely to underestimate actual prevalence as found in even a small sample. When asked to self-report "Do you have HF?" eight of 94 (8.5%) responded "no" (Gilotra et al., 2017).

Temporal trends in incidence and prevalence may be affected by variability in the reliability of diagnostic criteria used to diagnose HF, the reliability of other methodologies that rely on self-report or billing codes for the diagnosis of HF, and methodologies that rely on the

occurrence of a hospitalization event to identify a quantifiable case of HF (Dunlay & Roger, 2014). Incidence and prevalence estimates are also affected by the population examined, with Medicare beneficiaries demonstrating higher incidence rates compared to young populations. Moreover, lifetime risk is high, with 20-45% of individuals age 45 to 95 estimated to acquire a diagnosis of HF. Lifetime risk of HF was similar amongst White (32-39%) and Black (24-36%) females. Disparate lifetime risk of HF was estimated in White men (30-42%) versus Black men (20-29%) due to competing mortality risks for Black men (Huffman et al., 2013). The sustained incidence, increasing prevalence, and significant lifetime risk create the strong imperative to improve all aspects of care, including effective measures to prevent excess hospital readmission associated with the diagnosis of HF.

Risk Factor Prevalence and Cost of HF

Risk factors for HF are common, with at least one risk factor present in up to 33% of the US adult population (Benjamin et al., 2018). Coronary artery disease, hypertension, diabetes mellitus, obesity, and smoking are responsible for 52% of incident HF cases (Heidenreich et al., 2013). Lack of optimal control of blood pressure, cholesterol, diabetes, smoking, and body mass is estimated to account for 88.8% of incident HF events (Dunlay & Roger, 2014). Racial disparities and dietary and lifestyle factors are also significant contributors to HF risk (Heidenreich et al., 2013). Demographic risk factors include older age, male sex, ethnicity, and low socioeconomic status (Heidenreich et al., 2013). Dunlay and Roger (2014) reported that the risk factor prevalence of hypertension, hyperlipidemia, and smoking has declined, while the prevalence of obesity and diabetes has risen.

Associated total cost for HF in 2012 was estimated to be $30.7 billion, of which 68% was attributable to direct medical costs. Heidenreich's model also projects a 127% increase in total cost to $69.7 billion by 2030 (Heidenreich et al., 2013). Notably, potential costs could rise as

much as $160 billion in direct cost alone by 2030 (Heidenreich et al., 2013). Hospitalizations (including readmissions) are prevalent after an HF diagnosis, with 83% of patients hospitalized at least once and 43% hospitalized at least four times, and represent a substantial portion (75%) of the cost of HF care (Dunlay & Roger, 2014; Heidenreich et al., 2013). Total individual lifetime costs were $109,541,[11] with the majority accumulated during hospitalizations (mean $83,980 per person; Dunlay et al., 2011).

Other factors that affect cost include the use of long-term care facilities and the impact of advanced heart failure therapies. Discharges to a skilled nursing facility (SNF) increased among Medicare beneficiaries from 6.8% in 1980-84 to 13.4% between 2000-2004 (Dunlay & Roger, 2014). Further, 24.1% of Medicare beneficiaries in an evidence-based prevention program were discharged to an SNF after an HF hospitalization (Dunlay & Roger, 2014). More than 50% of HF hospitalizations to SNF expire within one year (Dunlay & Roger, 2014). Advanced heart failure therapies such as organ transplants and left ventricular assist devices (LVAD) are costly, and eligible patients represent only a small fraction of all US cases of those living with HF (Dunlay & Roger, 2014). The prevalence of risk factors in the US population, the increasing prevalence of obesity and diabetes, the associated cost for care, and potentially significant increases in the future cost of care for patients with HF indicate a significant imperative to improve the care and management of individuals with HF. Interventions such as HFPC may address the burden of disease and decrease costs predominantly by decreasing hospital readmissions.

Mortality and Comorbidity

After the initial diagnosis of HF, survival is 72-75% at one year and 35-52% at five years, which has significantly improved in recent decades, nonetheless indicating a diagnosis with

[11] 95% CI [$100,335 - 118,946]

substantially high mortality rates (Dunlay & Roger, 2014). While efficacious for symptom management, established HF treatment alternatives such as diuretics, ultrafiltration, vasodilators, inotropes, and spironolactone have demonstrated no mortality benefit in large, well-conducted clinical trials (Rayner-Hartley et al., 2018). Multiple comorbidities in HF constitute a significant burden of medical complexity in HF populations: renal insufficiency, atrial fibrillation, and COPD or asthma, and increase the complexity of medical management (Rayner-Hartley et al., 2018).

A recent review of characteristics of patients attending the ED for HF noted an increased prevalence of previous coronary artery bypass graft (CABG) or percutaneous coronary intervention (PCI), hypertension, peripheral vascular disease (PVD), stroke, and diabetes in patients less than 80 years compared to those older than 80 (Claret et al., 2016). Older patients were more likely to present with additional comorbidities such as atrial fibrillation, dementia, and chronic renal failure (Claret et al., 2016). The challenges of a clinical syndrome with high mortality, complex medical management of multiple comorbidities, and challenges with identifying interventions with associated mortality benefit create the imperative for identifying new strategies, such as HFPC, for improved management of patients with HF.

Summary

The sustained incidence, increasing prevalence, and significant lifetime risk of HF create the strong imperative to improve all aspects of care associated with the diagnosis of HF. The prevalence of risk factors in the US population, the increasing prevalence of obesity and diabetes, the associated cost for care, and potentially significant increases in the future cost of care for patients with HF indicate a significant imperative to improve the care and management of individuals with HF. The challenges of a clinical syndrome with high mortality, complex

medical management of multiple comorbidities, and challenges with identifying interventions with associated mortality benefit create the imperative for identifying new strategies, such as palliative care to prevent HF hospital readmission, to improve management of patients with HF.

Historical Review of the Literature Relating to Hospital Readmission for HF

A complete historical review of the literature for this investigation of whether HFPC is an effective intervention to reduce 90-day hospital readmissions requires an in-depth understanding of the numerous factors that contribute to the issues pertaining to HF readmissions, including (a) the emergence of the hospital readmission metric, (b) the economic burden of readmission for hospitals, (c) risk factors associated with hospital readmission, (d) the burden of symptoms for HF patients, (e) HF readmission rate trends since the implementation of HRRP, (f) mortality trends associated with hospital readmission initiatives, and (g) an understanding of the complexities of HF medical management that must be considered when identifying an effective strategy to reduce HF readmissions. These factors create the impetus for developing innovative approaches to manage the HF patient population with HFPC consults that may serve as an effective method to reduce 90-day HF hospital readmissions.

The Hospital Readmission Metric

The earliest published literature on HF recognized the elements of the process of care, adequate patient education during discharge instructions, and prompt follow-up (Lewis, 1978). In the mid-1980s, the prevalence of HF was identified as a significant cause of hospital readmission; within a 6-month period after index hospitalization, 36% of patients with a primary diagnosis of HF experienced a hospital readmission (Gooding & Jette, 1985). Dunlay and Roger (2014) reported that heart failure is the leading cause of hospitalization among Medicare beneficiaries and has the highest 30-day readmission rate (~25%) of any diagnosis. Greater than 50% will be readmitted within one year; multiple readmissions are common and are associated

with high mortality (Dunlay & Roger, 2014). To create new strategies, CMS implemented incentives to encourage hospitals to address the issue.

Readmission rates were first introduced in 1953 to characterize risk among neuropsychiatric patients discharged from the Department of Veterans Affairs (VA) hospital (Jenkins et al., 1953). In 2005, to promote quality and manage costs, the Hospital Compare website was launched, introducing the metrics and proposed methodology for public reporting of hospital quality metrics (DeVore et al., 2016). In 2009, the American College of Cardiology (ACC) and the Institute for Healthcare Improvement (IHI) launched the Hospital to Home (H2H) initiative targeting a goal of reducing 30-day hospital readmission by 20% by December 2012 (American College of Cardiology & Institute for Healthcare Improvement, 2009). On July 9, 2009, CMS began to publicly report hospital 30-day all-cause risk-standardized mortality rates and 30-day all-cause risk-standardized readmission rates for AMI, HF, and pneumonia (Centers for Medicare and Medicaid Services, 2015; Krumholz et al., 2013). The 2010 Affordable Care Act implemented the HRRP on the premise that a hospitals' scope of responsibility should include post-discharge care coordination (Centers for Medicare and Medicaid Services, 2015; Chin et al., 2016). On October 1, 2012, CMS Medicare introduced penalties and started to reduce payments for inpatient hospitalizations if a hospital demonstrated a higher than expected versus predicted 30-day readmissions for multiple diagnoses, specifically identifying HF readmissions (Centers for Medicare and Medicaid Services, 2015; Davis et al., 2017).

The CMS implemented 30-day readmission rates based on hierarchical logistic regression models that were derived from Medicare claims data and adjusted for variation in hospital volume and case mix (McIlvennan et al., 2015). The metric was implemented despite limited evidence supporting the 30-day interval as an indicator of between-hospital variation in the

quality of care (Chin et al., 2016; National Quality Forum, 2016). Intracluster correlation coefficients (ICC) represent the proportion of risk explained by hospitals (between-hospital variation) compared to the total risk in the population (all variation). Poor 30-day readmission correlation was noted with ICC values of 4.8-5.3% for mortality measures and 1.5-2.6% for readmission measures. Further time-dependent analysis demonstrated a sharp reduction in the readmission ICC after the seventh day post-discharge,[12] suggesting that a significant proportion of the presumed hospital quality signal at 30 days may be attributed to characteristics of the individual or community setting of care such as the socioeconomic and demographic profile of the hospital's patient population, the hospital's resource availability, patient social support, or mental health issues (Chin et al., 2016; Pandey et al., 2017).

Similar findings were noted in a longitudinal review of index HF admissions from 2006 to 2009 in Australia with non-statistically significant interhospital ICC for 30-day unplanned readmission of 0.0125,[13] and statistically significant patient-level factors of age and comorbidity were more predictive of unplanned 30-day hospital readmission (Korda et al., 2017). In a large meta-analysis of hospital process indicators, 30-day readmissions were not associated with adherence to any of the CMS required hospital process indicators, indicating that the causation of readmissions lies outside of the purview of the acute hospital admission (Fischer et al., 2015; Pandey et al., 2017). Thus, it follows that selection of 30-day readmission rates as an indicator of quality is to encourage hospitals to assume responsibility for post-discharge adherence and primary care follow-up and likely represents a public policy intended to shift responsibility from individual care providers to systems of care, such as that embodied by multidisciplinary HFPC, to promote a more cohesive shared responsibility for continuity of care (Chin et al., 2016).

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[12] 78%, 49% and 76% among patients admitted with AMI, HF and pneumonia respectively

[13] $p = 0.24$

The development of readmission metrics is flawed as a measure of hospital quality of care. These metrics are more likely to represent administrative priorities to promote improved systems of care that include both individual and community aspects of care. HFPC may contribute to improved continuity of care and thereby result in fewer unplanned hospital readmissions.

Burden of Readmission for Hospitals

A recent evaluation of adherence to AMI acute and discharge performance measures showed an inequitable burden of readmission among hospitals serving patient populations with higher levels of social disadvantage and higher illness acuity (Pandey et al., 2017). Compared to White patients and non-minority serving hospitals, Black patients and minority-serving hospitals demonstrated an increased risk of all-cause readmission for HF[14] in a large analysis of more than three million Medicare recipients, notably prior to initiation of HRRP (Joynt et al., 2011). Consequently, hospitals with a high prevalence of socially or medically complex patients carry the greatest burden of readmissions and are more likely to be penalized, raising questions of whether CMS readmissions penalties are equitably and justly applied (Joynt & Jha, 2013; Pandey et al., 2017).

Hospitals with the highest readmission rates are more likely than hospitals with lower readmission rates to care for patients who are (1) younger, Black, not married, less educated, retired, (2) have fewer total assets, lower household income, and a Medicare disability, (3) are Medicaid enrolled, (4) have an absence of supplemental health insurance, a current smoking status, multiple comorbidities, depression, lower cognition, lower self-rated health, fewer household residents, and multiple difficulties with activities of daily living (ADLs), mobility and

[14] *OR* 1.04, 9 `5% CI [1.03 - 1.06] and 1.14, 95% CI [1.11 - 1.17]

agility (Barnett et al., 2015; Freedland et al., 2016). Hospitals that serve a higher percentage of patients enrolled in both Medicare and Medicaid (dual-enrolled) were 20% more likely to have excess readmissions using the CMS methodology than hospitals that served a lower percentage of patients with dual-enrolled statuses, indicating that hospitals that serve a more disadvantaged population are disproportionately subject to payment reduction penalties under HRRP; this difference was reduced to 0 by adjusting for individual dual eligibility status and hospital share of patients with dual eligibility (Gu et al., 2014). The equity issues described herein are the subject of broad debate and represent issues beyond the defined scope of this investigation but are nonetheless a necessary background to understand the complications associated with emerging HFPC initiatives.

Previous studies among patients with HF have likewise failed to demonstrate a strong association between in-hospital quality of care and 30-day readmission rates (Fischer et al., 2015). Studies have established a temporal decline in HF readmissions but may be confounded by changes in coding rather than improvements in care (Desai et al., 2016; Jha, 2015; Zuckerman et al., 2016). The evidence suggests there is an emerging imperative for HRRP outcome metrics to be reevaluated to align with the evidence that acute care and discharge quality metrics do not appear to influence readmissions, and hospital readmissions are often attributable to individual and community aspects of care. The hospital burden of care is disproportionately distributed. Hospitals with the highest readmission rates tend to bear the responsibility for sicker, poorer, less educated patients with fewer social supports. These hospitals are also more likely to incur payment reduction penalties for excess 30-day HF readmissions. These issues are relevant to this investigation in that if health systems are encouraged to divert resources to ensure HFPC referral and access to services, HFPC must be established as an effective intervention to reduce 90-day

hospital readmissions, especially for health systems that already struggle with caring for the highest risk patients in a situation of limited resources.

Trends in HF Readmissions Since HRRP

An annotated detailed summary of findings pertaining to HF readmission rates is included in Appendix A1. In summary, initial support for the introduction of the HRRP was strong, identifying multiple reasons for excessive 30-day readmission rates that, if properly managed during the inpatient admission, may reduce readmission rates[15] (Berenson et al., 2012). The HRRP also embeds accountability in the system, as hospitals are no longer able to abdicate responsibility for patients after they leave but instead remain accountable for what happens to patients in the post-discharge period, resulting in improved discharge planning and care coordination (Jha, 2015). However, caution was also advised that the implementation of the HRRP may have unintended consequences for the care of vulnerable populations and older adults (Gu et al., 2014; Naylor et al., 2012). Ultimately, HFPC may bridge the gaps between hospital discharge and primary care physician follow-up.

A 2000-2011 community study of Olmsted County, MN residents, identified rates of readmission that were highest during the first 30 days then decreased precipitously after. A minority were readmission for heart failure (17%). More often, the reason for hospitalization was another cardiovascular (32%) or non-cardiovascular (51%) cause (Chamberlain et al., 2017). The authors noted that in order to reduce hospitalizations in patients with HF, an integrated approach focusing on comorbidities is required (Chamberlain et al., 2017). HFPC may be the modality to achieve this integration.

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[15] hospital-acquired infections and other complications, premature discharge, failure to coordinate and reconcile medication, inadequate communication among hospital personnel, patients, caregivers and poor planning for care transitions

HF Mortality Trends

HF mortality trends are an important aspect of this study because the dependent variable, HFPC consult, seeks to impact the post-discharge period, and differential mortality may affect the assessment of the outcome of interest—90-day hospital readmission. The causes attributable to mortality surrounding HF hospitalization are not well understood. One hypothesis is that hospitalization events are uniquely followed by a time-dependent, transient, biologic vulnerable state for all patients, characterized by hemodynamic and neurohormonal abnormalities and end-organ damage (Dunlay et al., 2010; Gheorghiade et al., 2012). Temporal changes in mortality risk before and after HF readmission demonstrate a net increase in predicted mortality risk[16] after readmission with a nadir at 90 days, demonstrating a persistent mortality risk that never returns to pre-readmission levels (Cook et al., 2016).

A single state review of readmissions between 1998-2001 found a 12-month mortality rate of 41% with a 30-day readmission versus a mortality rate of 27% amongst propensity-matched patients without a 30-day readmission (Arundel et al., 2016). Evaluating patient characteristics and a marked 37% net increase in mortality post HF readmission in a global, randomized clinical trial identified characteristics associated more often with a patient's individual clinical risk profile rather than risk relative to hospitalization itself (Cook et al., 2016). Korda et al. (2017) observed statistically significant associations with patient-level characteristics of age and severe comorbidities for 30-day hospital readmission versus hospital-level characteristics. Simply put, 30-day readmission captures the patient with worsening clinical symptoms requiring admission rather than the hospitalization itself being causative to the resulting mortality risk (Cook et al., 2016). Palliative care may provide the needed transition and

[16] *HR* 37%, 95% CI [23% - 53%]

continuity of care to address the observed increase in mortality risk associated with hospitalization.

Readmission Trends and Associated Mortality

Results are mixed with regard to readmission trends and associated mortality and annotated results; an annotated summary can be found in Appendix A2. Early evidence assessing mortality outcomes since the implementation of HRRP showed absent or non-statistically significant trends (Bergethon et al., 2016; DeVore et al., 2016). However, early caution was raised about the potential consequences of the HRRP with concerns about the metric itself, suggesting a risk of shifting hospital expenditures to focus on reducing readmissions at the expense of more urgent quality improvement efforts and introducing punitive measures for readmission in hospitals that have achieved low mortality rates with higher readmission rates (Joynt & Jha, 2012). In a comprehensive review of the HRRP program, 30-day readmission rates for HF were unchanged over time while noting a statistically significant increase in mortality after implementation of public reporting (DeVore et al., 2016).

Emerging evidence has demonstrated the potentially harmful if unintended effects of the HRRP, with emerging evidence of increased mortality associated with continuing implementation (Bueno et al., 2010; Dharmarajan et al., 2017; Fonarow et al., 2017; Gupta et al., 2017; Krumholz et al., 2013). In a secondary analysis of previously published results on readmission and mortality, researchers identified a statistically significant negative correlation between the longitudinal trend in mortality rates and readmission rate[17] (Krumholz et al., 2009; Krumholz et al., 2013). The caution offered by the authors that the "relationship was only modest and not throughout the entire range of performance" (p. 590) is of interest; however, stratified

[17] $r2$ =-0.17, 95% CI [-0.20 to -0.14]

analysis revealed consistent statistically significant inverse correlations regardless of key hospital characteristics of teaching status, ownership status, safety net status, or geographic location (Krumholz et al., 2013). A comparison of mortality trends pre- and post-intervention identified no statistically significant differences between hospitals participating in the Premier Hospital Quality Incentive Demonstration (HVBP hospitals) and hospitals not participating (non-HVBP hospitals), which were more likely to include small, private, non-teaching critical access hospitals in the South and Midwest exempt from CMS penalties (Figueroa et al., 2016). While there was no statistically significant difference in mortality trend between HVBP and non-HVBP hospitals, both categories witnessed a reversal in the observed mortality trend for HF with rates declining in the pre-intervention period[18] and statistically significant increases of 0.02 and 0.03, respectively, in the post-intervention period (Figueroa et al., 2016). If findings of increased mortality in the post-discharge period are accurate, HFPC may provide the needed transition and continuity of care to minimize mortality differences.

Controversy continues on the validity of the association of the HRRP with mortality evaluated in a cross-sectional study with poor baseline performers in HF quality metrics demonstrating a decrease in mortality[19] while all other hospitals demonstrated an increase in mortality[20] (Chatterjee & Joynt Maddox, 2018). A large retrospective cohort study inclusive of 3.2 million HF hospitalizations evaluating the four periods of HRRP implementation identified consistent increases in 30-day post-discharge mortality[21] (Wadhera et al., 2018). A second large retrospective cohort study using similar sampling methodology and time period identified four

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[18] -0.7 for HVBP hospitals and -0.11 for non-HVBP hospitals

[19] 13.5 to 13.0%

[20] 10.9 to 12.0%

[21] 0.27%, 0.49% and 0.52% for the respective intervals of baseline change prior to HRRP announcement, change after HRRP announcement but prior to implementation, and change after HRRP implementation

million HF hospitalizations. A key difference was the inclusion of inpatient mortality events, which included an additional 800,000 cases accounted for by a calculated 2% mortality rate of cases not included in the study population of Wadhera et al.'s (2018) research (Khera et al., 2018). Thirty-day post-discharge mortality increased between 2006 and 2014; however, the researchers qualified that finding with the observation that 30-day post-discharge mortality also increased prior to the announcement of the HRRP, which suggests that observed increases are expected (Khera et al., 2018).

In addition, in their final presentation of results, the authors combined the decreasing trend of in-hospital mortality with the increasing trend of 30-day post-discharge mortality to illustrate their conclusion that there was no statistically significant overall change in HF mortality as measured by the composite of post-admission mortality (Khera et al., 2018). In summary, the authors make a dualistic argument that there are no statistically significant increases in overall post-admission mortality. If that argument is not sufficient, the observed increases are wholly attributable to the natural and expected increases in overall HF mortality. Mortality remained a significant source of variability and was an important confounder for this evaluation of the impact of HFPC on 90-day hospital readmissions.

HRRP has been moderately successful at reducing hospital readmissions after an index HF admission. It is also likely that the reduction in HF hospital readmissions is associated with an increase in HF mortality. Studies to date have not stratified the HF population to determine what subgroups are at the highest risk for increased mortality, but it is intuitive to propose that those with Stage III, IV HF or meeting eligibility criteria for a palliative care referral would be most likely to be at highest risk. An annotated summary of studies pertaining to HF readmission rates and mortality can be found in Appendix A2.

Risk Factors for Readmission

Risk factors for readmission identified in previous studies include:

- comorbidities of diabetes, chronic lung disease, renal failure, or electrolyte imbalance. Fifty percent of readmissions were due to a cardiac cause, pulmonary causes (13%), renal causes (9%), smoking status, alcohol intake, depression, and lower cognition score.
- characteristics of the hospital stay and disposition, including patients with a prolonged hospital admission greater than one week and patients discharged to an SNF or home with a nurse
- interventions during the acute hospitalization, including transfusion during the index admission
- demographic characteristics of older age, less education
- economic characteristics of fewer total assets, lower household income, Medicare primary insurance or Medicaid enrollment, absence of supplemental health insurance, and absence of prescription drug coverage.
- social isolation, including no living children, no living siblings, no friends living nearby and infrequent contact with friends, poor self-rated health, difficulties with activities of daily living (ADLs), decreased mobility and decreased agility (Arora, Patel, et al., 2017; Barnett et al., 2015; Freedland et al., 2016; Mirkin et al., 2017).

These studies demonstrate the scope required of a program to effectively reduce hospital readmissions and reflect the necessary scope of socioeconomic, health literacy, and psychosocial considerations that need to be considered in efforts to successfully address hospital readmissions (Barnett et al., 2015). Hospital-focused interventions alone can contribute little, while

interventions like palliative care offer a broader scope to address the highly variable patient circumstances that need to be addressed. These elements represent important co-factors for this investigation and are represented within the demographic and severity characteristics included in this investigation.

Patient Drivers of HF Hospital Readmission

Patient perception of symptoms and the reasons for hospital readmission are important to understanding the issues that improve the self-management of HF and decrease unnecessary hospital readmission. HFPC may directly affect patient perception of symptoms to seek hospital readmission. Hospital admission for HF is associated with fatigue, drowsiness, dyspnea, anxiety, decreased well-being, and edema. In one review, up to 58% of patients reported that symptoms had not improved an average of four days after hospital discharge compared to admission (Khan et al., 2015).

Patient-identified reasons for HF admission include worsening heart failure, dietary nonadherence, or other worsening medical condition; only a small proportion (4%) did not know, had no access to a provider, or reported a medication issue (Gilotra et al., 2017). Physician perspective agreed with patient perceptions on issues of dietary nonadherence, but physicians were much more likely to identify a medication issue as a major reason for HF admission. Patients identified three major themes relating to reasons for hospital readmission: a lack of caregiver support and personal motivation to provide self-care: “I can’t take care of myself, and I can’t find anybody who can provide care” (p. 539), acceptance of condition and desire for aggressive care: “I ain’t going nowhere, and I’m fighting” (p. 539), and access to care and poor quality of care: “I have problems, medical, psychological, financial and every day I’m out, it gets worse” (p. 539; Enguidanos et al., 2015).

Perception of illness related to personal control and treatment beliefs about the necessity of medications versus adverse effects have been noted to be significantly associated with medication adherence, which is a critical aspect of care for the success of interventions that aim to reduce hospital readmissions (Turrise, 2016). In the Journal of the American Medical Association (JAMA) forum, Jha (2015) eloquently advocated that "during an acute illness, patients prioritize survival, maintaining functional status, cognitive clarity, being treated with dignity, and reducing pain. Reducing hospital readmission, while important, is likely a lower priority for patients" (p. 1681).

Perception of symptoms, medication and dietary adherence, perceived social support, cognitive and economic capabilities to provide self-care, perception of illness, and access to care influence an individual's ability to provide self-care sufficient to appropriately reduce unnecessary hospital readmission. HFPC may directly affect patient perceptions of these co-factors and influence subsequent health-seeking behaviors, giving patients the confidence to accurately interpret their symptoms and thereby avoid unnecessary hospital readmissions.

Strategies for Reducing HF Readmissions

Interventions that have demonstrated the potential to decrease hospital readmissions include (a) the development of risk prediction models, (b) optimizing medical therapy, and (c) health system strategies (Ziaeian & Fonarow, 2016). A myriad of interventions have since been proposed to decrease the number of HF readmissions and may encourage inappropriate care strategies to achieve a reduction in readmission rates (Bradley et al., 2013; Woolhandler & Himmelstein, 2016). HFPC is typically considered a health system strategy that may provide the needed transition and continuity of care to optimize compliance with medical therapy.

Validated risk prediction models have shown poor discrimination in their ability to predict hospital readmission—c-statistic range 0.55 - 0.65 (Burke et al., 2017; Kansagara et al.,

2011; Krumholz et al., 2016). Cognitive testing as a part of routine clinical care during hospitalization has shown greater predictive performance of hospital readmission, and inclusion of cognitive testing in other models improved predictive accuracy (Patel et al., 2015). Inclusion of measures of health literacy and functional and cognitive status may improve predictive models, but further validation is required (Ziaeian & Fonarow, 2016).

Optimizing medical therapy may include advanced heart failure interventions such as cardiac resynchronization therapy, ultrafiltration, and left ventricular assist devices; however, they are costly, and eligible patients represent only a small fraction of all US cases living with HF (Al-Khazaali et al., 2016; Dunlay & Roger, 2014). Cost-effective medication management may include digoxin, beta-blockers, aldosterone inhibitors, angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARB), or a new combination product Sacubitril or Valsartan that has shown efficacy in managing HF (Khder et al., 2017; Ziaeian & Fonarow, 2016). Remote monitoring, whether by telephone or via embedded impedance technology in ICD or CRT devices, did not improve outcomes or reduce readmissions but increased admissions due to increased monitoring (Chaudhry et al., 2010; Jayaram et al., 2017; Krumholz et al., 2016). Implantable pulmonary artery sensors that wirelessly transmit pulmonary artery pressure measurements offer the potential to reduce HF readmissions up to 58% in a single-blind trial but are reliant on the fidelity of data and timely response to information (Abraham et al., 2011). Statistically significant health system strategies to reduce hospital readmissions include partnering with community physicians, local hospitals, nursing responsibility for medication reconciliation, arranging follow-up appointments before discharge, a process to send discharge summaries directly to the patient's primary physician, and assigning staff to follow-up on test results that return after patient discharge (Bradley et al., 2013). The issue remains that while each

intervention contributed statistically significant reductions to HRR, the effect size was limited, ranging from -0.18% to -0.34% (Bradley et al., 2013).

Effective interventions to reduce HF readmissions must include medical management, early reassessment, health literacy, assessment of neuropsychological status, financial means, and assessment of functional status (Sperry et al., 2015). Current fragmented strategies cannot deliver a comprehensive scope of services required to decrease hospital readmissions and improve patient outcomes. HFPC may be a plausible and feasible health system strategy to improve compliance with treatment interventions and thereby decrease 90-day hospital readmissions.

Summary

The development of readmission metrics is flawed as a measure of hospital quality of care. Readmission metrics are more likely to reflect administrative priorities to promote the development of improved systems of care that incorporate individual and community aspects of care more likely to contribute to improved continuity of care and result in fewer unplanned hospital readmissions. HFPC may be a plausible and feasible modality of care delivery to achieve the objective of reduced HF hospital readmission. The hospital burden of care is disproportionately distributed, and hospitals with the highest readmission rates carry the responsibility for sicker, poorer, less educated patients who have fewer social supports. These hospitals are also more likely to incur payment reduction penalties for excess 30-day HF readmissions.

Mortality risk increases after hospital readmission and never returns to pre-admission levels. Palliative care may provide the needed transition and continuity of care to address the observed increase in mortality risk associated with hospitalization. HRRP has been moderately

successful at reducing hospital readmissions after an index HF admission. It is also likely that the reduction in HF hospital readmissions is also associated with an increase in HF mortality. Studies to date have not stratified the HF population to determine what subgroups are at the highest risk for increased mortality, but it is intuitive to propose that those with Stage III, IV HF or meeting eligibility criteria for a palliative care referral would be most likely to be at highest risk. Assessment of mortality is a previously unassessed and yet high-risk source of confounding and is a key aspect of this investigation.

The scope required of a program to effectively reduce hospital readmissions should include components that address socioeconomic, health literacy, and psychosocial considerations. Perception of symptoms, medication and dietary adherence, perceived social support, cognitive and economic capabilities to provide self-care, perception of illness, and access to care influence an individual's ability to provide self-care sufficient to appropriately reduce unnecessary hospital readmission. Effective interventions should include medical management, early reassessment, health literacy, assessment of neuropsychological status, financial means, and assessment of functional status. Current fragmented strategies cannot deliver a comprehensive scope of services required to decrease hospital readmissions and improve patient outcomes. Hospital-focused interventions alone can contribute little, while interventions like palliative care offer a broader scope to address the highly variable patient circumstances that need to be addressed.

This study assessed the effectiveness of the entry point of access to palliative care services, the initial palliative care consult. Whether palliative care consultation resulted in the delivery of a sufficiently broad scope of interventions to meet palliative care standard of practice is beyond the scope of this research. This dissertation study assumed that appropriate PC

interventions are delivered at the discretion of the PC provider individualized to the needs of each patient. Future research efforts on service delivery of palliative care should assess the elements that are evidenced-based and consistently delivered, how they are documented as complete, how progress is measured and the ideal timeline for service delivery. This study focused on the entry point to service delivery to determine whether the presence of a single PC consult alone, as defined and required by CMS, could result in a reduction in hospital readmissions.

Historical Review of the Literature Relating to HFPC

Lastly, a full review of the literature pertaining to this investigation requires an understanding of the definition and evolution of palliative care, including (a) the variation in the trajectory of disease that requires careful consideration when applying a service traditionally developed to provide care for terminal cancer patients, (b) the breadth of recommendations and position statements that advocate for the use of palliative care in patients with HF, and (c) trends and barriers for implementation of HFPC consistently and reliably.

Definition of Palliative Care

Palliative care is defined by the US Department of Health and Human Service (HHS), Centers for Medicare & Medicaid Services (CMS) and the National Quality Forum (NQF) as "patient and family-centered care that optimizes quality of life by anticipating, preventing, and treating suffering" (Braun et al., 2016). A comprehensive palliative care intervention includes assessment and management of physical symptoms, psychosocial and spiritual concerns, and advance care planning (National Consensus Project, 2018). Palliative care throughout the continuum of illness involves addressing physical, intellectual, emotional, social, and spiritual needs and facilitates patient autonomy, access to information, and choice (Dahlin, 2013). The

simplified definition proposed in the 4th Edition of the National Consensus Project (NCP) clinical practice guideline for quality palliative care embodies three elements: (a) comprehensive physical, emotional, spiritual, and social assessment, (b) skilled management of pain and other distressing symptoms, and (c) expert communication about what is most important to patients and families and implementing care plans to achieve those goals (National Consensus Project, 2018). Unlike hospice, palliative care is offered simultaneously with medical treatment (Gelfman et al., 2017).

The palliative care movement began in the 1970s as a grassroots community hospice movement aimed at caring for cancer patients in their homes (Adler et al., 2009). Medicare added hospice services to its benefits in 1982 (Connor, 2007). The trajectory of declining health in HF is very different from the trajectory of declining health associated with cancer. As such, the model of palliative care services that has been developed to meet the needs of patients with cancer may not translate well to meet the needs of patients with HF (Murray & Sheikh, 2008). Unlike cancer, HF exacerbations are unpredictable, advanced therapies are expensive and limited in their availability, and outcomes remain uncertain (Gelfman et al., 2017). Palliative care treatment models for HF have vastly improved in specificity and complexity and recognize the specific pathophysiologic changes and variable trajectory of declining physical function unique to HF (Goodlin, 1997, 2005, 2009; Morrison & Meier, 2004). In 2005, the American College of Cardiology and American Heart Association guidelines for the first time included recommendations that included discussion with patients and families about prognosis for functional capacity and survival, advance directives, palliative care and hospice care (Hunt, American College of, & American Heart Association Task Force on Practice, 2005).

This perspective on a new approach to HFPC is seen in the earliest investigations evaluating PC, suggesting a broader approach to chronic illnesses, noting that "the transition model of hospice care does not serve HF patients well, as most do not want to choose between curative treatment and symptom relief. A broader model of palliative medicine would offer aggressive symptom management and comprehensive care to the large percentage of outpatients with advanced illness who are still pursuing aggressive management or cure of their disease" (Rabow et al., 2004, p. 83).

Hospice Care. Palliative care and hospice care are separate and distinct concepts that are often mistakenly used interchangeably but have important differences. Palliative care is a broadly inclusive term describing all aspects of care that focus on improving quality of life and symptom control over curative therapy. Hospice is a defined subset of palliative care patients with an imminently life-limiting illness and has important implications for health insurance benefits (McIlvennan & Allen, 2016). This distinction is important, as bias persists among patients and providers that palliative care referral is equivalent to hospice care and is a major barrier to provider referrals and patient uptake of referral (Kavalieratos et al., 2014). This perception has driven efforts to rebrand HFPC as an intervention for patients with 'advanced' HF versus 'end-stage' HF and attempts to reduce the pernicious stereotype that palliative care is an option only of last resort (Kavalieratos et al., 2016).

Guidelines. The advocacy for palliative care to be made available to advanced HF patients is broadly advocated and embodied in numerous guidelines and consensus statements from:

- World Health Organization (Davies & Higginson, 2004)

- American Academy of Hospice Palliative Care Medicine (American Academy of Hospice Palliative Medicine, 2004)
- Consensus statement on palliative and supportive care in advanced heart failure (Goodlin et al., 2004)
- European Society of Cardiology (Jaarsma et al., 2009)
- Canadian Cardiovascular Society (McKelvie et al., 2011)
- Centers for Medicare & Medicaid Services (Centers for Medicare & Medicaid Services)
- American Heart Association scientific statement (Allen et al., 2012)
- International Society for Heart and Lung Transplantation (Feldman et al., 2013)
- Centers for Medicare & Medicaid Services decision memo for ventricular assist devices (Centers for Medicare & Medicaid Services, 2013)
- Joint Commission for the Accreditation of Hospital Organizations ("Modified: Ventricular assist device destination therapy requirements, 2014")
- Heart Failure Society of America (Fang et al., 2015)
- American Heart Association and Heart Failure Society of America: HF in Skilled Nursing Facilities (Jurgens et al., 2015)
- Geriatrics Section of the American College of Cardiology (Kirkpatrick et al., 2016)
- American Heart Association (Braun et al., 2016; Heidenreich et al., 2013)
- American Stroke Association (Braun et al., 2016)
- American College of Cardiology (Yancy et al., 2017; Yancy et al., 2013)
- National Consensus Project (National Consensus Project, 2018)

Despite the prevalence of guidelines and consensus statements, the evidence to establish the efficacy and effectiveness of palliative care to improve outcomes in HF is preliminary; a US national strategy for palliative care does not exist and remains an unrealized opportunity to improve value in health care (Meier, 2011; Meier et al., 2017). Highlighting the paucity of literature available to cardiologists, a review of the literature from 2009-2013 quantifying publications on HFPC found only 11 (0.1%) articles in the predominant cardiology journals on the topic of HF with PC as the main topic and an additional six (0.0%) with palliative care as a specific mention (Xie et al., 2017). Palliative care journals performed marginally better, with 47 (1.2%) of PC articles listing HF as a main topic and another 17 articles (0.4%) listing HF as a significant mention (Xie et al., 2017). Representation of the topic in cardiology conference proceedings demonstrated similar poor performance, with only 21 (1.2%) HF seminar sessions and 17 (0.4%) poster presentations listing PC as a main topic (Xie et al., 2017). This performance is largely driven by the absence of funding for HFPC, with <0.1% of federal funding for HF allocated to research on PC, only 21 (0.7%) grants funded with HFPC as a main topic, and another 13 (0.4%) with PC as a significant mention from the 2,921 HF grants funded by federal sources from 2009-2013, despite its prevalence and emphasis in a broad array of guidelines and consensus statement (Xie et al., 2017).

In 2017, only one paper evaluating HFPC was selected for presentation at the annual assembly of the American Association of Palliative and Hospice Medicine (AAHPM) and the Hospice and Palliative Nurses Association (HPNA) as a study with significant potential for impact on hospice and palliative care practice. The study was subsequently evaluated as having a high risk of bias. Additionally, it was conducted in a very different health care setting in Hong Kong (Gelfman et al., 2017; Kavalieratos et al., 2017; Taylor et al., 2017). In 2016, a National

Institutes of Health, National Palliative Care Research Center sponsored workshop was convened to outline the current research base, identify knowledge gaps and research priorities (Gelfman et al., 2017). The summary statement of the current evidence from the newly formed Improve Palliative Care Therapies for Patients with Heart Failure and Their Families (IMPACT-HF2) workgroup concluded that the current state of the science for palliative care in HF is limited, and further evidence is required to: (1) better understand advanced HF patients' limiting symptoms and focus treatment on their relief, (2) better characterize and address the needs of the caregivers of advanced HF patients, (3) improve patient and family understanding of HF disease trajectory and importance of advance care planning, and (4) determine the best models of palliative care, including models for those who want to continue life-prolonging therapies (Gelfman et al., 2017). This research proposal addressed research priority #2 of the NIH, NPCRC to better characterize and address the needs of the caregivers of advanced HF patients by evaluating an area of key interest to caregivers regarding whether palliative care consultation in a general medical population can reduce 90-day hospital HF readmission without increasing mortality.

Trends of Palliative Care Utilization

There has been a significant trend of increased HFPC over time, with utilization trends in veterans with severe heart failure increasing from 6% to 10% from 2007 to 2013. Overall, 51% of patients with HF died within one year of hospitalization. Patients seen by PC had a 1-year mortality of 72.8% compared to 49.5% among those who were not seen by PC[22] (Mandawat et al., 2016). Fromme et al. (2006) emphasized that the observed reduction in hospital readmission rates was undoubtedly lower because of the differential mortality that occurred within the

[22] $p < 0.001$

palliative care consultation group. Outcomes demonstrating the benefit of PC utilization should consider this differential mortality; however, studies to date have failed to do so.

Access to PC programs is variable across the United States, with the lowest prevalence of PC programs found in the South-Central regions. Even among hospitals with 300 or more beds, 12% of hospitals in the South did not have a current palliative care program (Dumanovsky et al., 2016). The resulting unmet need for palliative care in US hospitals was quantified with an observed extreme hospital-level variation from 12% to more than 90% of eligible patients receiving palliative care referral or services (Szekendi et al., 2016).

Enrollment in PC programs has also demonstrated marked variability. Patients enrolled in PC are more likely to be White, older, female, exhibit multiple comorbidities, access acute care services such as ER visits, hospitalizations, and ICU admission, and be receiving services in a long-term care setting than patients with cancer (Bain et al., 2009; Cheung et al., 2013; Setoguchi et al., 2010). A more in-depth evaluation of racial differences noted a persistent disparity over time, with non-White individuals eligible for hospice services 20% less likely to enroll and more likely to disenroll[23] in services compared to Whites (Unroe et al., 2012). Non-Whites accessing PC services were more likely than Whites to be younger, exhibit a higher frequency of comorbidity, reside in a state with Medicaid buy-in, and live in a non-rural location (Unroe et al., 2012). The perceptions associated with PC among patients self-described as familiar with PC services include many negative perceptions about it being a service to provide "comfort to dying patient and family," "for dying patients," or "comfort care." Increasingly positive perceptions include "team effort towards the patient to provide everything the patient needs," "semi holistic approach to care," or "pain relief, patient comfort, support for family."

[23] 11.6% versus 7.2%

Others have perceived PC as an assistive service described as “help with day-to-day activities, not in a hospital setting,” “visiting nurse who gives medications,” or “home care for elderly and sick” (Khan et al., 2015, p. 1713-1714). Among patients eligible for PC services, only 22% reported familiarity; however, 68% were interested in receiving PC services, which indicates that there is potential to address unmet needs associated with HF that is not being effectively managed by existing patient management systems (Khan et al., 2015).

Barriers and Supports for implementation of HFPC

In a recent multisite, retrospective, point prevalence study, the majority of patients appropriate for referral (60.9%) received neither referral nor services and identified barriers to referral, including (a) no standard definition of palliative care, even within organizations resulting in subjective referral criteria and variation in clinical practice patterns, (b) specialist reluctance to refer because of long-standing patient relationships and desire to retain patient management, (c) variable educational opportunities available to clinicians to acquire skills in primary palliative care, and (d) a perceived conflict that has the provider motivated to provide advanced specialty care and patient acceptance of not “doing everything” (Szekendi et al., 2016, p. 363). This variation in referral patterns has remained consistent over time, as demonstrated in a 2007 benchmarking study that assessed adherence to quality improvement metrics for palliative care and found wide variability in the provision of key performance measures that varied from 0% to 100% (Twaddle et al., 2007).

Factors propelling the adoption of HFPC services include (a) increasing referrals over time as HFPC teams develop relationships with frontline physicians and caregivers become aware of the value of HFPC services, (b) impression that HFPC teams should be reserved for the management of complex symptom management and when difficult patient and family dynamics arise, (c) support from hospital leadership who view HFPC as aligning with the achievement of

strategic goals to reduce readmissions, (d) increasing public awareness among patients and providers, and (e) increased focus on the hospital mission to provide patient-centered care (Szekendi et al., 2016). Of note is the paucity of research demonstrating efficacy or effectiveness as a factor promoting the adoption of HFPC services. Several studies have focused on demonstrating the benefit of HFPC for the hospital system and reductions in hospital readmissions, length of stay, and overall cost reduction (Bharadwaj et al., 2016; Lukas et al., 2013).

HFPC has been advocated to alleviate the symptom and psycho-social burden associated with advanced HF (Alpert et al., 2017; Dahlin, 2013). Compared to patients receiving cancer PC, HFPC patients experience a similar panel of symptoms, including (in declining rate of frequency) fatigue, anorexia, dyspnea, pain, insomnia, depression, anxiety, constipation, agitation, diarrhea, and nausea (Kavalieratos et al., 2014). Symptoms that were improved by HF hospitalization include nausea, anorexia, dyspnea, depression, edema, and decreased well-being; symptoms unmet by the hospitalization included pain, fatigue, drowsiness, and anxiety and may represent an opportunity to improve patient outcomes with services that are available and fall within the purview of HFPC services (Khan et al., 2015). While many symptoms improved during hospitalization—fatigue (60%), anorexia (28%), dyspnea (25%), pain (20%), insomnia (18%), depression (18%), and anxiety (13%)—they remained as major sources of unresolved symptom in HFPC patients (Kavalieratos et al., 2014).

Summary

A model of palliative care that recognizes the specific pathophysiologic changes and variable trajectory of declining physical function unique to HF is offered simultaneously with medical treatment, which embodies (a) comprehensive physical, emotional, spiritual, and social

assessment, (b) skilled management of pain and other distressing symptoms, and (c) expert communication about what is most important to patients and families and implementing care plans to achieve those goals. Despite the prevalence of guidelines and consensus statements, the evidence to establish the efficacy and effectiveness of palliative care to improve outcomes in HF is preliminary. A US national strategy for palliative care does not exist due to the nascent emergence of the palliative care physician specialty and high geographic variability of PC services and PC providers. It remains an unrealized opportunity to improve value in health care. This research addressed (a) the paucity of research demonstrating the effectiveness of HFPC to reduce hospital readmissions and (b) research priority #2 of the NIH, NPCRC, to better characterize and address the needs of the caregivers of advanced HF patients by evaluating an area of key interest to caregivers regarding whether palliative care consultation in a general medical population can reduce 90-day hospital HF readmission without increasing mortality. Outcomes demonstrating the benefit of HFPC utilization must consider the ascertainment bias of differential mortality; however, studies to date have failed to do so.

Research Literature Specific to HFPC

As discussed in the preceding historical review of the literature on heart failure, hospital readmissions, and palliative care, the increasing prevalence of HF coupled with the increasing cost associated with care, the complicated burden of HF symptoms, and comorbidities in the context of increasing regulatory and financial pressures to decrease hospital readmissions have promoted the adoption of novel strategies such as the adaptation of palliative care treatment models in the HF patient population. This section provides a more current review of the literature specifically pertaining to palliative care for patients with HF (HFPC) in a policy environment,

promoting a reduction in hospital readmissions for HF, and describes the theoretical framework of this investigation.

Readmissions

According to Dharmarajan et al. (2013), 20-25% of hospitalized HF patients will be readmitted within 30 days. Seventy percent of hospitalized HF patients will be readmitted within one year. Two-thirds of HF patients readmitted within 30 days will be readmitted for a condition other than HF. Evidence of the efficacy of palliative care consults to reduce readmissions for HF often cite palliative care studies that were performed in mixed populations, with heart disease representing only a small (5%-16%) proportion of the study population (Enguidanos et al., 2012; Fromme et al., 2006; Lukas et al., 2013). A retrospective observational review of palliative care enrolled by traditional referral patterns identified a statistically significant decreased 30-day hospital readmission rate of 14% for HF patients compared to non-enrolled subjects with a hospital readmission rate of 40% (Brian Cassel et al., 2016). The former reflects a rate similar to contemporaneously observed readmission rates post-HRRP implementation, while the latter reflects a rate significantly above general readmission rates observed for HF (Zuckerman et al., 2016). Resource use was significantly less in a retrospective observational study of palliative care enrollees compared to a propensity-matched cohort of HF patients predominantly driven by a reduced number of hospitalizations and length of stay (Brian Cassel et al., 2016).

Establishing the Goals of Care

Palliative care for HF has a primary objective to focus on improving quality of life rather than focusing on improving survival alone through medical interventions. The aim is to alleviate physical and psychological symptoms, support spiritual concerns, and create the opportunity to discuss goals of care (Teixeira et al., 2016). Inpatient palliative care consultation has been

demonstrated to decrease the frequency of procedures near the end of life, decrease the length of stay, and decrease hospital and overall costs of care, such as pharmacy and imaging (Adler et al., 2009).

Resuscitation preferences in HF have been noted to change over the course of the disease, with 75% of patients electing do-not-resuscitate status before death, yet marked discordance exists between patients' primary recovery goals and treating clinicians' goals who often do not effectively elicit patients' needs, concerns and expectations regarding their care (Dunlay et al., 2014, Figueroa, 2016). In a recent single-site review at a large academic medical center, 20% of patients hospitalized with HF indicated a resuscitation preference that differed from what had been ordered by clinicians in the same hospitalization (Young et al., 2017). Guidelines routinely recommend discussions about prognosis and patient preferences for goals of care, advance care planning, surrogate decision making, and social and spiritual support; however, a cross-sectional analysis of a cohort study identified 32% had not discussed prognosis, 24% had not discussed what to expect in the future with respect to their HF diagnosis, 54% had not discussed advance care planning, and 77% had not discussed religion or spirituality preferences (Gordon et al., 2017). Shared decision-making and future care planning are essential elements of HFPC and routinely employ communication methods with demonstrated effectiveness, such as motivational interviewing (Meyers & Goodlin, 2016; Riegel et al., 2016).

Systematic Reviews and Randomized Clinical Trials

Multiple systematic reviews specifically relevant to the topic of HFPC have compiled the limited evidence available and largely focus on the prevalence of bias in much of the existing literature and the previously reviewed findings gleaned from the few remaining well-conducted

studies with minimal risk of bias (Diop et al., 2017; Fischer et al., 2015; Kane et al., 2015; Kavalieratos et al., 2016; Kavalieratos et al., 2017; Maciver & Ross, 2018; Singer et al., 2016).

The systematic reviews and randomized clinical trials that have contributed to the evidence on HFPC are summarized in an annotated table found in Appendix A3. Only one study has been rated as having a low risk of bias. The mixed results and methodological issues present in these studies demonstrate the preliminary status of the evidence to guide assessment, patient management, and effective treatment interventions to achieve desired patient outcomes for decreasing symptom burden, improving quality of life, and optimizing resource utilization with decreasing hospital readmissions without increasing the risk of mortality. Previous evidence reviewed has demonstrated evidence for the potential of increased mortality associated with decreased hospital readmissions. Any policy that improves resource utilization should not come at the cost of increased risk of mortality. It is an important aspect of palliative care research to provide evidence that palliative care not only improves symptom burden, quality of life, and decreased hospital readmission but does so with no increased risk.

Alternatively, HFPC may be the only safe and effective way to decrease hospital readmissions with the home-based services of PC. The hypothesis of this investigation was that the increased level of resources, education, facilitated decision-making, and future health planning would enable the patient to better understand their symptoms and improve health behaviors through a better understanding of the health system, and enable the patient to seek health care services in less hospital-oriented settings to ultimately decrease hospital readmissions. Also, this research evaluated whether or not an HFPC consult is associated with hospital readmission at 90 days after controlling for mortality. If an HFPC consult is associated with decreasing hospital readmissions after controlling for mortality, this would indicate a

positive finding and evidence of efficacy for HFPC consultation (reject the null hypothesis). If an HFPC consult is not associated with decreasing hospital readmissions after controlling for mortality, this would indicate a negative finding for HFPC consultation (fail to reject the null hypothesis). No study to date has evaluated patient outcomes in a propensity-matched cohort to evaluate the effect that mortality may have on the rate of hospital readmissions.

Sidebottom et al. (2015) demonstrated non-significant differences in mortality in a population with marked differential loss to follow-up with 80% of intervention arm patients not completing intervention follow-up. Brannstrom and Boman (2014) and Rogers et al. (2017) found non-significant differences in survival or mortality at follow-up in resource-intensive health services environments atypical for health services in much of the United States. In the absence of such resource-intensive health services, it is intuitive that HFPC may be the only resource available to HF patients to achieve the outcomes of decreasing hospital readmission without increasing mortality. To attempt to decrease hospital readmissions without additional self-care support would intuitively be a significant risk of increased mortality, especially in the setting of observed increases in mortality associated with HRRP efforts to decrease hospital readmissions for HF.

Retrospective Studies

The most frequent method of investigation of HFPC has been the retrospective cohort analysis. The findings from this approach have also had the highest frequency of mixed findings. Two recent large studies, conducted at large academic medical centers, produced directly contradicting findings (Chuang et al., 2017; Wiskar et al., 2017). Chuang et al. (2017) identified no reduction in risk of 30-day hospital readmission in the HFPC group compared to a propensity-

matched control group[24]. Wiskar et al. (2017) identified a significant reduction in hospital readmission for HF[25] and all-cause readmission[26] at nine-month follow-up. There were key differences in these two studies, the former, a single-site academic medical center, the latter, a linked nationwide analysis; the former monitored follow-up for 30 days and the latter for 90 days (Chuang et al., 2017; Wiskar et al., 2017). Both studies matched on severity using validated comorbidity indices. Neither study evaluated the effect of mortality despite differential mortality (39% - 37%) and differential average time to death (136-262 days) in the HFPC group compared to controls in the former study, an analysis that was perhaps unnecessary, given the existing absence of an observed association; in the latter study, mortality was not assessed, which was a significant limitation to the findings (Chuang et al., 2017; Wiskar et al., 2017).

A previous study at a single-site large academic medical center identified statistically significant reductions in 30-day hospital readmission, with rates for HFPC recipients showing 10.3%[27] versus usual care at 15%[28] (O'Connor et al., 2015). The authors acknowledged that at least some of the effect size might have been due to hospice referrals; mortality was not assessed in the cohort (O'Connor et al., 2015). In addition, the observed readmission rates were substantially different from rates in later retrospective studies and other studies evaluating HF readmission rates alone, suggesting fundamental differences in admission practice or ascertainment bias (Chuang et al., 2017; Desai et al., 2016; Wiskar et al., 2017). Earlier retrospective studies were predominantly descriptive in nature, included HF in a mixed

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[24] respectively, 50.8% and 36.0%
[25] 9.3% vs. 22.4%, $p < 0.01$
[26] 29.0% vs. 63.2%, $p < 0.01$
[27] 95% CI [8.9% - 12.0%]
[28] 95% CI [14.4% - 15.4%]

population, and evaluated implementation strategies for advance care planning and hospice use (Bekelman et al., 2011; Connor et al., 2007; Enguidanos et al., 2012; Schellinger et al., 2011).

Prospective and Before-After Intervention Studies

The majority of prospective studies have been small studies of HFPC models of care to test the feasibility of a planned future larger intervention study (Bekelman et al., 2014; Dionne-Odom et al., 2014). One prospective case-control study is notable for its specific methodology using multiple validated measures of comorbidity, symptoms, depression, and quality of life at baseline and 90-day follow-up, with statistically significant improvements noted in each of the domains measured (Evangelista et al., 2012). Patients were excluded if they were currently receiving or had planned HFPC services; limitations noted included the small groups, lack of randomization, and the case-control method to test association without the ability to evaluate causality (Evangelista et al., 2012).

Several non-randomized before-after HFPC intervention trials have been published describing the phased implementation of HFPC for advanced HF at single sites of inpatient and outpatient care (Bailey et al., 2005; Nelson et al., 2011; Pattenden et al., 2013). The bias of the historical control in the setting of rapid evolution and advocacy for the implementation of HFPC from published guidelines is significant (Gordis, 2009). One before-after HFPC intervention trial evaluated the effectiveness of a single RN versus an interdisciplinary team consisting of a physician, bioethicist, social worker, RN, and hospital chaplain. The study noted a 20% reduction in six-month hospital readmissions, p =0.025, with a calculated Bayesian probability of readmission of 73% for each individual in the former group, while the latter group had a calculated Bayesian probability of readmission of 33% (Nelson et al., 2011).

Cross-sectional Studies

Other studies have included descriptive cross-sectional prevalence studies defining the availability of PC services, quantifying the unmet patient need for palliative care services, and resource utilization (Blecker et al., 2011; Szekendi et al., 2016; Twaddle et al., 2007). These analyses have identified significant gaps in the human resource and organizational capacity to deliver HFPC to eligible patients. A point prevalence study of 33 hospitals identified 18.8% of the inpatient populations as appropriate for palliative care referral. Of those deemed appropriate, 39.1% received a palliative care referral or services, with wide variation in service delivery ranging from 12% to more than 90% (Szekendi et al., 2016). These findings indicate a sizable unmet need for PC services in general, which increases the demand for additional PC resource demands; the evidence supports the efficacy of the HFPC intervention to achieve the outcome desired-decreased hospital readmissions.

In a review of 35 major US teaching hospitals, 12 (35%) did not have PC consultation available (Twaddle et al., 2007). The level of performance achieved on key performance measures rivaled that of hospitals where PC consultation was available but not utilized or requested late in the hospitalization. Hospitals with no PC consultation available achieved an average of 53.8% successful completion of key performance measures, while hospitals with PC consultation achieved 69.3% adherence to key performance measures when PC was received compared to 59.8% when it was not received (Twaddle et al., 2007). These findings demonstrate that PC services may be successfully delivered to the HF patient even in the absence of a specific PC consultation service, indicating the potential for innovative program design that maximizes the reach and utility of PC practitioners. These findings are also important to the definition of what constitutes delivery of PC. The definition is limited to the presence or absence of a requested PC consultation to the completion versus non-completion of a requested PC

consultation or delivery of the PC services, regardless of whether or not such services are provided in the context of a formal PC consultation.

Qualitative Studies

A limited number of studies have evaluated questions important to the practice of PC, such as goal definition and assessment of PC service delivery (Schellinger et al., 2018; Schwarz et al., 2012). Evaluating a mixed population comprising 68% with a primary diagnosis of HF, Schellinger et al. (2018) identified 13 unique domains that are essential to whole-person care. These findings provide an essential guide to achieving a comprehensive, holistic PC assessment that goes beyond the focus on physical, disease-specific, problem-oriented medical care.

Cost-effectiveness Studies

Cost-effectiveness for HFPC has not been evaluated in the United States. Sequential studies evaluating the cost-effectiveness of PC indicate that pooled diagnostic categories were statistically significant, while stratification demonstrated a stronger association with cancer versus non-cancer diagnoses (May et al., 2014; May et al., 2018). In a statistical analysis accounting for multiple comparisons, statistically significant cost-effectiveness only remained among non-cancer patients with an Elixhauser comorbidity index > 4, indicating that PC is cost-effective for those with non-cancer diagnoses with four or more multiple comorbidities (Elixhauser et al., 1998; May et al., 2018; Moore et al., 2017). Cost-effectiveness for home-based HFPC has been clearly established in Sweden, with statistically significant reductions in MD visits, emergency transport, and hospital care (Sahlen et al., 2016). Costs were increased for nurse visits and other primary health care visits, which resulted in non-significance for total combined costs. However, despite non-significant changes in costs, there was also a statistically significant increase in quality-adjusted life years, contributing to an overall favorable outcome

for the cost-effectiveness determination (Sahlen et al., 2016). The limitation for generalizability of these findings to the United States is the fundamental differences in the health system priorities, health care preferences, and priorities of the United States versus Sweden. Whether HFPC is cost-effective in the US health system remains undetermined.

Theoretical Framework

The theoretical framework for this research is nested within the foundational science of signal detection theory (Goldstein, 1999). The process of sensation and perception can be separated into the physiological process of neural transmission and the psychological process of perception, recognition, and action (Goldstein, 1999). The psychological process that prompts behavior is best described by Leventhal's Common-sense model of self-regulation of health and illness (CSM). Leventhal's Common-sense model is broadly used throughout the HFPC literature (Dionne-Odom et al., 2014; Horne et al., 2013; Turrise, 2016).

Signal Detection Theory

The sensations of sight, hearing, smell, taste, and touch inform our perceptions through established physiological pathways, but also through the cognitive influences formed by an individuals' ability to remember and recognize grouping patterns, context, previous knowledge, familiarity with the method of delivery, and expectations based on culture, past experiences, and memory (Goldstein, 1999). The physiological pathways of sight, hearing, and touch are augmented by the chemical senses of taste and smell that form the individual's ability to perceive their presence and position in this world (Goldstein, 1999). The physiologic pathway comprises a distal stimulus (diagnosis of HF), a proximal stimulus (symptoms of HF), transduction (transformation of sensory input to electrical energy), and neural processing (transmission to neuronal pathways). The subsequent psychological process comprises the elements of perception

(interpretation of symptoms), recognition (contextual meaning of symptoms), and action (outcome of the perceptual process; Goldstein, 1999).

Signal detection theory is the theoretical basis of measuring perception. It has two essential components, the 'signal,' which is the stimulus presented to the subject, and 'noise,' which is all the other stimuli in the environment that can sometimes be mistaken for a signal because the signal is usually very faint (Goldstein, 1999). This describes the complexities of the chronically ill HF patient struggling to differentiate signals of worsening disease from the noise of chronic illness with incredible accuracy. For example, in a signal detection experiment, an individual must interpret the presence or absence of a signal in the context of varying background noise. An individual who is motivated, intrinsically or extrinsically, to identify as many signals as possible will be a liberal responder and demonstrate a high sensitivity, low specificity, and a high false-positive rate of activation (Goldstein, 1999). An individual who is motivated to be 'sure' of the presence of a signal before responding will be a conservative responder and demonstrate a lower sensitivity, higher specificity, and a lower false-positive rate of activation (Goldstein, 1999).

An important and directly applicable aspect of the theory is that if the payoff or reward for identifying a signal is high, all subjects will become liberal responders and demonstrate a high sensitivity and consequently high false-positive rate of activation, precisely the motivational system that is in place for the care and management of patients with HF (Goldstein, 1999). A high-valued reward (health) will be realized if the patient can identify as many signals as possible indicating a problem with their underlying disease that prompts them to seek expert opinion via medical care. Simultaneously, government and insurers provide incentives to health systems and health care providers to provide optimal care within existing resources that will limit

the need for hospital resources, to be ‘gatekeepers’ for hospital readmission, and from the patient’s perspective, limit access to the reward.

Varying the reward in a signal detection experiment will yield a ROC curve that would enable the investigator to determine whether individual responses exhibit the same or significantly different sensitivity to the signal regardless of their inherent high or low responder tendency. However, in an experiment with HFPC, it would be unethical to vary the reward, and as such, a natural or observational study design is required. In this type of study design, a response that can be evaluated is the presence or absence of 90-day hospital readmission for HF. By providing improved coping mechanisms, HFPC may improve the accuracy of perceived signals (symptoms), thus decreasing unnecessary health-seeking behaviors and consequently decreasing unnecessary 90-day hospital readmissions.

Common Sense Model

The Common Sense Model (CSM) was proposed as an information-processing model that holds that individuals (a) interpret the meaning of illness and symptoms, (b) decide how to respond, (c) take action, (d) evaluate the effectiveness of the action or illness management strategy, and (e) revise their understanding of the criteria for evaluating the effectiveness of the action (Leventhal et al., 2003). CSM focuses on how patients shape their health-seeking behaviors based on their illness beliefs. The issues related to immunization during the ongoing COVID-19 pandemic clearly illustrate how extreme illness beliefs related to conspiracy theories, governmental interference, or wholesale fraud in the actual existence of the disease has shaped health-seeking behaviors related to obtaining the vaccination, with many individuals choosing to not be immunized despite clear risks to their own health and the health of others. Theories related to the CSM and over-arching model of self-regulation provide interpretations of illness

via an explanatory construct of chronic illness representation and focus on how people with chronic somatic disorders make sense of their illness (Kaptein et al., 2003). Goals and confidence are key self-regulatory elements that influence action (Scheier & Carver, 2003). Important aspects of medication adherence have been further described in the perceptual context of treatment risk versus side effects and are elaborated in the necessity-concerns framework (Horne, 2003). The effects of culture, gender, personality, cognition, and denial related to the application of the CSM have been described in detail (Baumann, 2003; Cameron, 2003; Contrada & Coups, 2003; Martin & Suls, 2003; Wiebe & Korbel, 2003).

In the CSM, illness representations are formed by both individual experience and social inputs and have (a) an identity, label, or name associated with the condition (HF, HF exacerbation), (b) a timeline or perceived rate of onset, duration, and decline (progression of HF stage), (c) consequences or anticipated physical, cognitive and social disruption (decline in function, death), (d) a cause (heart attack as a cause of HF or idiopathic cause of HF), and (e) control or the perceived effectiveness of the ability of self or medical interventions to manage disease (Leventhal et al., 2003). Similar to the previously discussed signal detection theory, in which the signal must be accurately interpreted as present or absent in the context of background noise, the CSM provides insight into why patients with HF often misidentify symptoms of concern. Breathlessness, chronic fatigue, and swollen feet may be clear signs of HF for a physician but may be misinterpreted by the patient due to their previous experience or illness prototype and an illness representation that may falsely minimize or exaggerate the identity, timeline, consequences, cause, and control of HF elements. These result in suboptimal illness outcomes of excessive hospital readmission or preventable mortality (Leventhal et al., 2016). In order to successfully manage their disease progression, HF patients must be able to accurately

and reliably identify symptoms associated with the condition, anticipate the progression of their disease, understand the consequences of specific medical and self-management choices or interventions, have knowledge of the cause of worsening symptoms and demonstrate an action plan exhibiting their ability to control their condition and measure the effectiveness of chosen self-management or medical interventions (Leventhal et al., 2016).

The CSM was chosen over other models of health behavior, such as the Health Belief Model and Theory of Planned Behavior because concepts in the CSM are multi-level. The CSM focuses on not only the antecedent experience of severity (illness prototype) but also concurrent inputs from the senses and treatment beliefs. It also considers the projected future consequences and potential for cure or control (illness representation) of the health-seeking behavior (Leventhal et al., 2016). Moreover, the CSM requires examination beyond the 'why' a specific behavior occurred; it examines the context, what an individual did, and how the behavior is achieved (Leventhal et al., 2016).

The CSM proposition that guided this dissertation study is that the relationship between illness representations with inputs from the illness prototype, sensory inputs and treatment beliefs, and the illness outcome of hospital readmission can be modified by improving coping procedures developed in the context of palliative care. Health care providers can do little to influence an individual patients' illness prototype, sensory inputs, or treatment beliefs. However, health care providers can provide the patient with coping procedures that may impact the illness outcome of interest—to decrease hospital readmission. This study evaluated the relationship of coping procedures, as measured by the presence versus absence of palliative care consultation with the illness outcome of 90-day hospital readmission.

It is reasonable to presume that achievement of high patient perception competency in coping procedures would be more effectively delivered within the physician-driven model of HFPC. However, the difficulty demonstrated in previous studies is that the observed variation in HFPC service delivery is high, and determining the threshold of whether HFPC services have been adequately delivered is difficult. If presence versus absence of an order for HFPC consult is the differentiator, the consult may occur during the inpatient hospitalization or not; if presence versus absence of an actual HFPC consult on the medical record is the differentiator, the type of services delivered is highly variable. Since patient knowledge and competency are at the core of successful disease management, it is irrelevant where the derived source for HFPC competency arises. Rather, knowledge and skills are received, understood, and incorporated by the patient to inform a more accurate and reliable illness representation. Consideration of the need and referral for palliative care consultation is a reasonable if unvalidated proxy for the intent of the entire patient care team to provide HFPC competency via a mixed approach with nursing-driven education; primary care self-care recommendations, future planning with advanced directives, and designation of health care proxy and coordination of services; subspecialist management recommendations; case management referrals for available community support services and ideally, palliative care consultation.

Summary of What is Known and Unknown About HFPC and Hospital Readmission

In summary, what is known and unknown about the relationship between HFPC and hospital readmissions is that the prevalence of HF is increasing and is unlikely to decrease with significant and sustained risk factor prevalence of coronary artery disease, hypertension, diabetes mellitus, obesity, and smoking in the population (Benjamin et al., 2018; Heidenreich et al., 2013). The economic burden for the management of HF in a model of healthcare designed for

acute care is unsustainable (Heidenreich et al., 2013). It is unknown whether HFPC is an effective alternative for patient management to improve outcomes for patients with HF.

The interpretation of symptoms and health-seeking behaviors for HF is complex, difficult to assess, and exerts a strong influence on the individual's illness representation, prompting health-seeking behaviors (Enguidanos et al., 2015; Kaptein et al., 2003; Leventhal et al., 2016; Turrise, 2016). Research demonstrates that coping mechanisms improve illness outcomes (Leventhal et al., 2016; Turrise, 2016). It is unknown whether improved coping mechanisms, represented by the presence of a PC consult, can affect the illness outcome of hospital readmission in patients with HF.

Research has shown that the HRRP policy that seeks to reduce hospital readmissions was based on an inherently flawed premise that the hospital may influence health-seeking behaviors for a 30-day period post-discharge (Chin et al., 2016; National Quality Forum, 2016). In addition, studies have shown that 30-day hospital readmissions were not impacted by related hospital process of care indicators but were associated with individual and community factors such as resource availability, social support, and mental health issues (Barnett et al., 2015; Chin et al., 2016; Freedland et al., 2016; Pandey et al., 2017). It is unknown whether the acute care hospital system can reasonably facilitate access to a limited resource, like PC consultation, with a limited number of PC practitioners to fully serve the HF population in need of services. It is also unknown whether different modalities of care, service delivery models, or location of service delivery of PC interventions can deliver comparable outcomes.

Lastly, the HRRP policy has met with a modicum of success in reducing 30-day HF hospital readmissions, but that reduction has continued controversy with its association with increases in post-discharge HF mortality. It is unknown whether improved coping mechanisms

delivered by HFPC can achieve reductions in hospital readmission without an increase in mortality. In other words, it is unknown if HFPC modifies the relationship between the HF illness representation and the illness outcome of hospital readmission without an increase in mortality.

Contribution

Practical application of the findings generated will:

- Contribute to the existing knowledge gap identified as a research priority by the NIH, NPCRC to better characterize and address the needs of providers managing the care of advanced HF patients.
- Contribute to the evidence evaluating the effectiveness of palliative care referral to reduce hospital readmissions for HF.
- Contribute to the evidence evaluating the relationship between a PC consult and 90-day hospital readmissions in a propensity-matched HF cohort, with adequate controls for the assessment of bias arising from differential mortality, an element that has been poorly assessed in the previous literature.

Chapter 3: Methodology

Research Methods

The approach to this research is a concurrent cohort design with a prospective ascertainment of 90-day hospital readmission, HFPC consult and mortality. To ensure the capture of all discharges and readmissions, all live discharges with a primary diagnosis of HF, codified in Appendix A4, were abstracted from the AdventHealth data warehouse. Data abstraction included patient identifiers to enable future contact, all coded administrative ICD-10 diagnosis codes, palliative care consult code, and mortality status and elements required to achieve propensity matching. The outcome of interest is hospital readmission for any cause within 90 days of index HF hospitalization. Readmission was assessed by medical record review and patient contact (if needed) conducted at 90-120 days post-discharge. IRB approval of the research plan, ascertainment of readmission, and mortality at 90 days post-discharge were ascertained in a stepwise manner:

1. All 90-day hospital readmissions captured within the AdventHealth Tampa database were supplemented with additional metrics abstracted from the electronic medical record to enable propensity matching.
2. Patients with an unascertained status at 90 days post index HF discharge were reviewed in the AdventHealth Tampa electronic medical record to determine readmission, palliative care consult, and mortality status.
3. Any remaining patients with an unascertained status at 90 days post-HF discharge were contacted directly with the contact information provided at the time of the index admission with a single query: “Has ‘patient name’ had any hospital admissions since

the discharge from AdventHealth Tampa on 'discharge date'?" after introductions defined by the IRB.

4. Any remaining patients with an unascertained status at 90 days post-HF discharge were determined to be lost to follow-up (Lorenz et al., 2008). Ascertainment of status at 90-day post HF discharge was high, with only one patient excluded as lost to follow-up.

CONSORT

The CONSORT flow diagram template was developed for standardized reporting of randomized clinical trials. It has been adapted to illustrate the research plan for this investigation (Schulz et al., 2010). Table 1 shows the index hospitalization for live HF discharges between October 1, 2019, and December 31, 2019.

Table 1

Index Hospitalization for Live HF Discharges

Index Hospitalization for Live HF Discharges	
	Oct 1 - Dec. 31, 2019
	N=150 (estimated)
Exclusions:	Age < 18
	Transfer to another acute care / psychiatric hospital
	Left hospital against medical advice
	Hospitalizations for the same condition within 30 days of an index hospitalization were not considered an index event.
	Patients alive but without at least 90 days of post-discharge follow-up.
Palliative Care Consult	No Palliative Care Consult
n=	n=
Propensity-matched cohort	Propensity-matched cohort
n=	n=

Excluded criteria used by Centers for Medicare & Medicaid Services (CMS) to calculate hospital mortality and readmission performance, but not used in this study:

1. Exclusion of patients who did not have a full year of pre-admission enrollment in Medicare.
2. Exclusion of patients alive but without at least 30 days of post-discharge follow-up.

Specific Methodological Procedures

Specific procedures defined herein make the analytic choices transparent to the reader and include a description of the specific plan to achieve propensity matching, the plan for logistic regression analysis, and the formats for the final presentation of results.

Analytic Choices

A key aspect of this investigation is the choice of analytic approach that was used. A review of the literature related to mortality and HF readmissions illustrated how different analytical choices can yield divergent results. Silberzahn et al. (2018) quantified the potential variability in the analytic approach with 32 equivalently competent research teams presented with the same dataset and research question and asked to determine a valid analytic approach and final result. The teams selected from one to seven covariates from the 14 covariates available; 15 (52%) chose a Logistic approach, six (20%) teams chose a Linear approach, six (20%) chose a Poisson approach, and two (7%) chose a miscellaneous approach. Results varied from *OR* 0.89 to 2.93; the theoretical approach, operationalization of the theory, statistical analytic choices, and the assumptions made during analysis can result in sizable variation in effect sizes even with a valid statistical methodological approach (Silberzahn et al., 2018). The authors recommended approaches that increase transparency in the analytic choices made and decrease the opportunity

for selective reporting. The description of research methods employed in this study ensured transparency of analytic choices with the aim to decrease the opportunity for selective reporting.

Logistic Regression

To answer the primary research question of interest, whether palliative care consultation can impact 90-day hospital readmission in a propensity-matched, mortality-adjusted HF population, the propensity-matched cohorts were compared in a logistic regression with the dependent variable of 90-day readmission and independent variables:

- Palliative care consult (Y or N)
- Propensity score (Continuous)
- 90-day mortality (Y or N)

The relationship between 90-day hospital readmission and PCHF consult was further explored with a graphical analysis of time to readmission with a Kaplan-Meier survival analysis regression evaluating the presence/absence of differential survival time to readmission predicted by palliative care consult, including only those patients who had an ascertained status of alive at 90 days, exclusive of the contribution of propensity.

Propensity Matching. Propensity matching has been used frequently in the HF literature to ensure appropriately matched cohorts (Brian Cassel et al., 2016; Chuang et al., 2017; Wiskar et al., 2017). Propensity-matched cohorts were formed based on the development of a propensity score for each HF index hospitalization case. The propensity score is the conditional probability of receiving an exposure (e.g., palliative care consult) given a vector of measured covariates. It can be used to adjust for selection bias when assessing causal effects in observational studies (Andrey et al., 2011). The propensity score is defined as the probability of receiving treatment based on measured covariates $e(x) = P(Z = 1 \mid X)$ where $e(x)$ is the abbreviation for propensity score, P a probability, $Z = 1$ a treatment indicator with values 0 for control and 1 for treatment,

the "|" symbol stands for conditional on, and X is a set of observed covariates (Thoemmes, 2012). The calculated propensity score enables matching on demographic characteristics and severity to ensure that patients who receive HFPC are matched to patients with a similar demographic and severity profile (O'Connor et al., 2015).

Propensity scores for receiving palliative care consult were calculated using a non-parsimonious multi-variable logistic regression model with the treatment variable of palliative care consult as the dependent variable and independent variable covariates (Chuang et al., 2017; Garrido et al., 2014; Gupta et al., 2017; National Consensus Project, 2018):

- age
- gender
- DNR status (Y or N)
- insurance coverage
    - Medicare
    - Medicaid
    - private
    - dual eligible
- last known cardiac ejection fraction
    - preserved
    - borderline
    - reduced < 25%
- ICD implant
    - ICD only
    - CRT-D only

    - ICD or CRT-D
- all administratively coded ICD-10 diagnosis codes to identify comorbidities identified in Appendix A5 (Elixhauser et al., 1998)
    - cardiac arrhythmias
    - valvular disease
    - pulmonary circulation disorders
    - peripheral vascular disorders
    - hypertension, uncomplicated
    - hypertension, complicated
    - paralysis
    - other neurological disorders
    - chronic pulmonary disease
    - diabetes, uncomplicated
    - diabetes, complicated
    - hypothyroidism
    - renal failure
    - liver disease
    - peptic ulcer disease, excluding bleeding
    - AIDS or HIV
    - lymphoma
    - metastatic cancer
    - solid tumor without metastasis
    - rheumatoid arthritis or collagen vascular diseases

    - coagulopathy
    - obesity
    - weight loss
    - fluid and electrolyte disorders
    - blood loss anemia
    - deficiency anemia
    - alcohol abuse
    - drug abuse
    - psychoses
    - depression
- severity of HF index hospitalization at time of admission
    - systolic blood pressure
    - heart rate
    - Na
    - BUN
    - creatinine
    - hemoglobin
    - parenteral inotrope therapy (dopamine hydrochloride, dobutamine hydrochloride, milrinone lactate)
    - intra-aortic balloon pump use during index hospitalization
    - current smoking
- adherence to guideline directed medical therapy determined by chart review
    - NYHA class I-IV —> ACEI or ARB

    - If NYHA class II-III with adequate BP control on ACE/ARB and no C/I to ARB or sacubitril —> D/C ACEI or ARB; initiate ARNI
    - If NYHA class II-III, LVEF <=35% (caveat: >1 year survival, >40d post MI) —> ICD
    - If NYHA class II-IV, LVEF <=35%, NSR & QRS >=150ms with LBBB pattern —> CRT or CRT-D
    - If NYHA class II-III, NSR< HR>=70 bpm on maximally tolerated dose beta blocker —> Ivabradine
- length of stay, days
- discharge destination
    - home
    - skilled nursing facility
    - inpatient rehabilitation facility
    - intermediate care facility
    - long-term care facility
    - hospice, home
    - hospice, inpatient

A logit of the propensity score enabled calculation of ORs for obtaining palliative care consultation for individual covariates (MedCalc Version 15.1, 2018).

$$logit(p) = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_kX_k$$

$$odds = \frac{p}{1-p} = e^{b_0} \times e^{b_1X_1} \times e^{b_2X_2} \times e^{b_3X_3} \times \ldots \times e^{b_kX_k}$$

In the final analysis, the use of a propensity score as a continuous variable will enable matching on demographic characteristics and severity. To ensure the inclusion of the maximum number of

observations, nearest neighbor-matching was employed because it reduces bias due to incomplete matching (Austin, 2013). The mean propensity score for the resulting palliative care and non-palliative care group before and after propensity matching was calculated, and a standardized difference was calculated. Residual imbalances in baseline covariates between treatment groups after propensity score matching was assessed by estimating the absolute standardized differences of the mean propensity scores (Austin, 2009). Standardized differences quantify the bias in the means (or proportions) of covariates across the groups, expressed as a percentage of the pooled standard deviation (Andrey et al., 2011). A t-test p-value was calculated to test statistically significant differences between the HFPC and non-HFPC groups before and after propensity-matching.

Demographic Characteristics. Additional demographic characteristics that were abstracted include:

- telephone contact information provided at the time of index HF admission.

Formats for Presentation of Results

CONSORT flow diagram summarizes the observed allocation of propensity matching, success with follow-up, and net cases included in the final analysis (Schulz et al., 2010). The resulting analysis is presented as tables demonstrating logistic regression of the primary research question of interest, whether 90-day readmissions can be influenced by HFPC consult after controlling for mortality and severity. The validity of this analysis is supported by tables of demographic characteristics before and after propensity-matching and calculated odds ratios for HFPC consult. Sub-analysis of time to readmission included calculated means and time to readmission. Survival curves demonstrate differential time to readmission for HFPC versus no-HFPC consult cohorts.

Logistic Regression

- table of the outcome of a logistic regression of 90-day hospital readmission after controlling for mortality and severity (propensity-scoring) in the propensity-matched population
- table of the outcome of a logistic regression of 90-day hospital readmission after controlling for mortality and severity (propensity-scoring) in the total un-matched population

Demographic Characteristics and Propensity Scoring of HFPC Versus Non-HFPC Cohorts

- table of demographic characteristics of HFPC versus non-HFPC cohorts before and after propensity-matching
- table of means and standardized differences of HFPC versus non-HFPC cohorts before and after propensity-matching
- box and whiskers plot of propensity scores stratified by HFPC versus non-HFPC cohorts

Odds Ratio

As a logit transformation of the individual B obtained from the logistic regression equation to demonstrate the effect size of the relationship, OR will be calculated.

- Odds ratio of 90-day hospital readmission predicted by the presence versus absence of a palliative care consult in propensity-matched, mortality adjusted cohort.
- Odds ratio of HFPC consult predicted by demographic characteristics, markers of acuity at the time of hospital admission, and other comorbidities.

Kaplan-Meier Survival Curve

- table of mean time to readmission
- histogram of time to readmission by cohort

- distribution of time to readmission by cohort
- Kaplan-Meier survival curve showing time to readmission for HFPC and non-HFPC patients in the total un-matched population (Chuang et al., 2017)
- Kaplan-Meier survival curve showing time to readmission for HFPC and non-HFPC patients in the propensity-matched population

Resource Requirement

The research relied solely on the effort of the investigator to develop and execute the approach, rationale, study design, data collection, and data analysis. The data warehouse required for data abstraction is maintained by AdventHealth Tampa, consistent with their current standard practice. Access to the data was pursuant to the procedures defined respectively by the State of Florida and AdventHealth and specifically interpreted for this study by the AdventHealth Tampa Institutional Review Board. A computer with Windows 10 operating system that utilized Endnote 8.0 software to support reference management, Scrivener software to support manuscript development, access to Grammarly.com to support editing, a current subscription for SPSS software to analyze the data, and Microsoft Office to support final publication.

Reliability and Validity

A strength of the approach outlined in this proposal is that this investigation assessed the outcomes of a cohort comprising 100% of individuals admitted for HF in the time period, pre-COVID Oct 1 - Dec 31, 2019, assessing the outcome of 90-day hospital readmission and accounting for mortality, minimizing the risk of ascertainment bias, and enhancing study validity and reliability. The impact of differential mortality between groups receiving and not receiving palliative care has been recognized as a significant risk of ascertainment bias in previous studies (Chuang et al., 2017; Desai et al., 2016; Hua et al., 2017; Wiskar et al., 2017).

Propensity scores assigned from the use of the validated Elixhauser comorbidity scoring system enabled the assignment of a propensity score based on a validated weighting of comorbidities and validated metrics of HF severity taken from the index hospitalization. The use of a validated scoring system to derive the propensity score creates the best opportunity to ensure the greatest homogeneity of each cohort, creating the best opportunity to observe differential outcomes between cohorts should they, in truth, exist.

Timeline

The execution of this investigation from the time of IRB submission was estimated to be:

- four weeks IRB submission.
- four weeks IRB clarifications and edits.
- four weeks Execute electronic data request to site.
- six weeks Data abstraction from medical records.
- six weeks Compilation of all data into analysis file.
- six weeks Data analysis.
- six weeks Preparation of dissertation results and discussion.

The actual timeline required approximately one year compared to the estimated six months, primarily due to the need to obtain multiple IRB approvals and unanticipated delays with compiling the data abstraction.

Chapter 4: Results

Chapter Introduction

This chapter reviews the compilation of the final dataset, provides a detailed review of the data analysis procedures and findings of the a priori data analysis plan, and discusses the findings of this investigation. The primary outcome of the propensity-matched, mortality-adjusted logistic regression showed that for every unit reduction in 90-day hospital readmission, there was a statistically significant 1.468 increase in no HFPC consult (reduction in HFPC consult), p =.001.

Compilation of Final Dataset

The final dataset used for analysis was compiled from multiple data output files that were compiled into a comprehensive dataset through a process of linking variables on four different patient identifiers. This compilation resulted in an n =268. After exclusion of an additional 18 cases that were expired (8), left the hospital against medical advice (AMA; 5), ineligible hospitalization (4), and discharged to Psychiatry (1), left a dataset n =250 for the index hospitalization period Oct. 1 - Dec. 31, 2019.

Multiple transformation and recoding of variables were required to transform individual vital signs and laboratory values that were output list-wise as a 'value' field, identified by case and specific test in the original data file into separate variables for each case. Likewise, selected comorbidities were organized as a subset of all comorbidities and transformed from unsorted lists into variables that defined the presence/absence of each selected condition for each respective identified index case. Lastly, the identification of the presence/absence of a 90-day hospital readmission was incorporated into the final dataset. Multiple readmissions were common in the original dataset and had to be de-selected, as they were not pertinent to this investigation. It is notable that at this juncture, when palliative care consults from the original datafile abstraction were matched to index hospitalization cases, no palliative care events

matched to the index hospitalization cohort. Despite employing validated methods for identifying palliative care consult occurrence, there were no coded PC events or any listed PC consults for this cohort of hospitalized HF patients. All PC consults listed were attributed to hospitalized cancer patients exclusively.

With a full cohort of index hospitalizations defined (n =254), data abstraction proceeded with the planned chart review abstraction of mortality events, ejection fraction (EF%), ACE/ARB use, presence/absence of ICD or CRT device implant, and IABP at the time of index hospitalization. It was at this juncture that insight was gained into the reason that there were no palliative care events listed in the abstracted data file. Due to the unique nature of the physician consult note naming convention, there is no standardized name for a "Palliative Care," "Cardiology," or any other type of consult. Each consult note is named according to the individual naming convention determined by the consulting physician. Thus, a cardiology consult may be listed as "Cardiology," but it also may be listed as "Florida Heart." All HFPC consults were consistently named "Palliative Care" and were thus available for abstraction as a part of chart review but could not be abstracted through automated means, as a standardized naming convention did not exist. Lastly, the final determination of mortality events at 90 days was largely determined by chart review and pharmacy utilization. Patient contact was required to determine mortality status in only two cases; one patient had moved out of the area, and the other's family represented the patient as both alive and deceased.

Transformation of Variables

All vital sign and laboratory values were normally distributed, including initial systolic blood pressure (SBP), initial heart rate (HR), initial sodium (Na), initial blood urea nitrogen (BUN), initial BUN/Creatinine ratio (BUN/Cr), initial Creatinine (Cr), initial hemoglobin (Hgb),

and initial hemoglobin A1C (Hgb A1C; see Appendix A7). Despite the presence of normal distributions for each of these variables, it was important to stratify these variables on established laboratory normals, which provided a greater level of clinical meaningfulness. While both continuous and stratified values are equivalent for the purposes of statistical analysis, the creation of clinically meaningful strata facilitates clinically applicable interpretation of results. For example, outcomes for patients that are hypotensive versus normotensive versus hypertensive are more clinically applicable than the statistically equivalent but less meaningful outcomes for single gradations of blood pressure or any other vital sign or laboratory value metric included in the model. In addition, directionality may not always be implicit in a continuous variable and would be a source of confusion in the interpretation of results. In this dataset, a very low or very high SBP or Na is clinically meaningful; that same interpretation does not apply to Hemoglobin (low is bad) or Cr (high is bad).

Stratification enables analysis against a pre-defined ‘normal.’ Categorical variable coding enabled the specification of a defined reference population and will allow the reader to draw meaningful conclusions more easily about the interpretation of the statistical associations with the outcome of interest. For example, mid-range or normal range of SBP was defined as the reference population, while the high range of values for EF% was defined as the ‘normal’ reference, and the low range of values for Cr was defined as the ‘normal’ reference group (See Appendix A8).

CONSORT

An overview of the data collection process and resulting population (*n*) is best reviewed with the CONSORT diagram. The CONSORT flow diagram template was developed for standardized reporting of randomized clinical trials (Schulz et al., 2010). It was adapted to illustrate the research plan and outcomes for data collection in this investigation. Table 2 shows the index hospitalization for live HF discharges between October 1, 2019, and December 31, 2019.

Table 2

Index Hospitalization for live HF Discharges: Oct. 1 – Dec. 31, 2019

Index Hospitalization for Live HF Discharges: Oct 1 - Dec. 31, 2019	
n=250	
Exclusions:	Age < 18 Transfer to another acute care hospital / psychiatric hospital Left hospital against medical advice Hospitalizations for same condition within 30 days of an index hospitalization were not considered index events. Patients alive but without at least 90 days of post-discharge follow-up.
Palliative Care Consult - Yes n=92	Palliative Care Consult - No n=142
Propensity-matched cohort[30] n=36	Propensity-matched cohort n=96

[30] This procedure excluded those that were so low on propensity scoring that likelihood to receive a PC consult was nil, and conversely excluded the population that scored so high on

Excluded criteria used by Centers for Medicare and Medicaid Services (CMS) to calculate hospital mortality and readmission performance, but not used in this study:

- exclusion of patients who did not have a full year of pre-admission enrollment in Medicare
- exclusion of patients alive but without at least 30 days of post-discharge follow-up.

Data Analysis

Data analysis was conducted in accordance with the a priori outlined data analysis plan. Logistic regression was used to assess the association of the independent variables of 90-day mortality, HFPC consult, and propensity score (severity) against the primary outcome of interest, 90-day hospital readmission. The analysis yielded statistically significant findings in the propensity-matched cohort; there were similar statistically significant findings in the overall unmatched study population. Key steps in this final analysis included:

1. Logistic regression of the primary research question of interest, whether 90-day hospital readmissions are influenced by HFPC consult after controlling for mortality and severity.
2. An analysis of demographic characteristics of the overall unmatched study population demonstrated statistically significant population differences that could confound the outcome of interest.
3. Propensity-matching enabled the creation of cohorts that were similar in severity and eliminated the potentially confounding population differences.

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propensity scoring that likelihood of PC consult was a certainty, n=132 was the final number included in the propensity-matched model.

4. Demographic characteristics of the propensity-matched population demonstrated similarity across a broad array of characteristics, with no residual demographic statistical differences.
5. A more in-depth analysis of risk factors predicting the occurrence of an HFPC consult was conducted with logistic regression of the individual predictor study variables for the outcome of HFPC.
6. A more in-depth analysis of time to readmission with survival analysis found statistically significant differences in the survival curve of time to readmission between patients who received an HFPC consult and those that did not. Findings were statistically significant in both the overall unmatched study population as well as the propensity-matched cohort.

Logistic Regression

Logistic regression was employed to assess the primary research question of this investigation. The primary outcome of interest, 90-day hospital readmission, was predicted by the independent variables of 90-day mortality, HFPC consult and propensity score (severity; see Table 3). Logistic regression was most applicable with a binary outcome of 90-day readmission (Y/N) and predictors that were binary (90-day mortality and HFPC consult), while propensity score was a continuous variable.

Propensity Matched Model. Outcomes of the logistic regression of the propensity-matched model found that for every unit reduction in 90-day hospital readmission, contributing factors were a:

- Statistically significant 1.468 increase in no HFPC consult (reduction in HFPC consult), p =.001

- .482 increase in mortality (no survivorship at 90-day), p =.36
- -0.631 reduction in severity, p =.50
- Palliative Care *OR* 4.3, 95% CI [1.8 - 10.6]

Table 3 shows the logistic regression of propensity-matched 90-day readmissions.

Table 3

Logistic Regression of Propensity-Matched 90-Day Readmissions

	B	S.E.	Wald	df	Sig.	Exp(B)
Palliative Care Consult (No)	1.468	.455	10.418	1	.001	4.342
Survivor @ 90-day (No)	.482	.531	.827	1	.363	1.620
Propensity_Match	-.631	.944	.447	1	.504	.532
Constant	-.779	.537	2.105	1	.147	.459

This analysis indicates that after controlling for mortality and severity, there is a statistically significant association between no HFPC consult and no 90-day hospital readmission. In other words, HFPC consultation is statistically significantly associated with hospital readmission within 90-day of discharge, after controlling for both mortality and severity. For every 1.5 HFPC consults performed, one 90-day hospital readmission will be predicted by this B trendline (e.g., if 30 HFPC consults are performed each month, 20 of those patients can be expected to have a hospital readmission within 90 days). The *OR* of 90-day hospital readmission for the HFPC consult cohort was *OR* 4.3, 95% CI [1.8 - 10.6], or patients who are appropriately targeted for an HFPC consult are four times more likely to have a 90-day hospital readmission than a patient who does not qualify for an HFPC consult.

Non-propensity Matched Model. To assess the robustness of the model without propensity-matching, a calculation of logistic regression for the total population was performed. Similar findings were noted with a logistic regression of the total unmatched population (see

Table 4). Results were similar in that for every unit reduction in 90-day hospital readmission, contributing factors were:

- statistically significant 1.44 increase in no HFPC consult (reduction in HFPC consult), p =.001
- 0.611 increase in mortality (no survivorship at 90-day), p =.12
- .460 increase in severity (propensity score), p =.44
- Palliative Care *OR* 4.2, 95% CI [1.8 - 10.1].

Table 4

Logistic Regression of Un-Matched 90-Day Readmissions

	B	S.E.	Wald	df	Sig.	Exp(B)
Palliative Care Consult (No)	1.442	.444	10.546	1	.001	4.231
Survivor @ 90-day (No)	.611	.388	2.486	1	.115	1.843
Propensity_Match	.460	.596	.594	1	.441	1.584
Constant	-.944	.491	3.701	1	.054	.389

This analysis demonstrated the robustness of the model in that even when the broader non-propensity matched population is used, statistically significant negative associations persist between HFPC consult and 90-day hospital readmission. In other words, HFPC consultation remains statistically significantly associated with hospital readmission within 90-day of hospital discharge after controlling for mortality and severity, even when outliers that were initially restricted from the propensity-matched analysis are included.

Demographics -Total Population. Evaluation of the demographic characteristics of populations to be compared in a statistical analysis is important to ensure that there are no significant differences in the two populations that could confound the outcomes of the analysis. At the very least, these population differences may call into question whether the existing

demographic differences are the primary cause of observed outcomes. There are numerous statistically significant differences between the cohort that had an observed palliative care consult compared to the cohort that did not. Table 5 demonstrates these differences.

Table 5

Demographic Characteristics - Total Un-Matched Study Population

		Palliative Care Consult						
			No			Yes		*p[31]
			Column			Column		
		Count	N %	Mean	Count	N %	Mean	
Age cohort	< 55	35	23.0%		17	17.3%		
	55-75	70	46.1%		38	38.8%		
	75+	47	30.9%		43	43.9%*		.037
Gender	Female	71	46.7%		56	57.1%		
	Male	81	53.3%		42	42.9%		
Do Not Resuscitate	.	148	97.4%*		85	86.7%		.001
	DNR	4	2.6%		13	13.3%*		.001
Primary Insurance	Commercial	102	67.1%		55	56.1%		
	Medicaid	6	3.9%		1	1.0%		
	Medicare	44	28.9%		42	42.9%*		.024
Secondary Insurance	None	76	50.0%*		34	34.7%		.017
	Commercial	47	30.9%		40	40.8%		
	Medicaid	26	17.1%		23	23.5%		
	Medicare	3	2.0%		1	1.0%		
Ejection Fraction % (Low)				.41			.43	
Ejection Fraction cohort	.25 Reduced	39	26.0%		24	25.0%		
	.25-.50 Borderline	58	38.7%		30	31.3%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

		Palliative Care Consult						
			No			Yes		*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
	.50+ Preserved	53	35.3%		42	43.8%		
Ejection Fraction % (High)				.46			.47	
AICD or CRT-	No	111	73.0%		74	75.5%		
D Implant	Yes	41	27.0%		24	24.5%		
ACE or ARB	No	55	36.2%		57	58.2%*		.001
Prescribed	Yes	97	63.8%*		41	41.8%		.001
Guideline	No	63	41.4%		60	61.2%*		.002
Adherence	Yes	89	58.6%*		38	38.8%		.002
Length of Stay				5			8	
Hospitalization	Admission	57	37.5%		36	36.7%		
duration	Observation	60	39.5%*		19	19.4%		.001
	Prolonged	35	23.0%		43	43.9%*		.001
Discharge	Home	101	66.4%*		38	38.8%		.000
disposition	Home w Services	28	18.4%		21	21.4%		
	Hospice – Home	0	0.0%		3	3.1%		
	Hospice – Facility	0	0.0%		8	8.2%		
	Inpt Rehab Facility	1	0.7%		2	2.0%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

			Palliative Care Consult					
			No			Yes		*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
	LTC Hospital	2	1.3%		2	2.0%		
	Short Term Inpatient	1	0.7%		1	1.0%		
	SNF -Skilled Nurse	19	12.5%		23	23.5%*		.024
90-day Readmit	No	99	65.1%*		39	39.8%		.000
	Yes	53	34.9%		59	60.2%*		.000
Survivor @ 90-day	No	19	12.5%		26	26.5%*		005
	Yes	133	87.5%*		72	73.5%		.005
BP	Hypertension	87	57.2%		59	60.2%		
	Hypotension	0	0.0%		2	2.0%		
	Normal	65	42.8%		37	37.8%		
HR.	Normal	108	71.1%		64	65.3%		
	Bradycardia	9	5.9%		3	3.1%		
	Tachycardia	35	23.0%		31	31.6%		
Na	Hypernatremia	4	2.7%		3	3.1%		
	Hyponatremia	26	17.4%		18	18.4%		
	Normal	119	79.9%		77	78.6%		
BUN/Cr	Low	20	13.4%		11	11.2%		
	Normal	83	55.7%		54	55.1%		
	Renal	46	30.9%		33	33.7%		
Cr	High	26	17.6%		13	13.7%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

			Palliative Care Consult					
			No			Yes		*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
	Elevated	38	25.7%		37	38.9%*		.029
	Normal	84	56.8%		45	47.4%		
Hgb	Anemia	79	53.0%		58	59.2%		
	Normal	69	46.3%		40	40.8%		
	Polycythemia	1	0.7%		0	0.0%		
Hgb A1C	Normal	21	42.0%		18	60.0%		
	Poor Control	17	34.0%		12	40.0%		
	Very Poor Control	12	24.0%		0	0.0%		
Pressors	No	145	95.4%		95	96.9%		
required	Yes	7	4.6%		3	3.1%		
Intra Aortic	No	152	100.0%		97	99.0%		
Balloon Pump	Yes	0	0.0%		1	1.0%		
Tobacco Use	Cognitive Def	0	0.0%		0	0.0%		
	Never	81	54.7%		57	58.8%		
	Last Tobacco Use <30d	22	14.9%		10	10.3%		
	Last Tobacco Use >1yr	37	25.0%		24	24.7%		
	Last Tobacco Use >30d <1yr	5	3.4%		4	4.1%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

		Palliative Care Consult						
			No			Yes		*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
	Unable to answer	3	2.0%		2	2.1%		
AIDS	No	151	99.3%		96	98.0%		
	Yes	1	0.7%		2	2.0%		
Alcohol abuse	No	151	99.3%		96	98.0%		
	Yes	1	0.7%		2	2.0%		
Alcohol abuse w mild liver dz	No	152	100%		98	100%		
	Yes	0	0.0%		0	0.0%		
Deficiency Anemias	No	117	77%*		64	65.3%		.044
	Yes	35	23.0%		34	34.7%*		.044
Arthropathies	No	145	95.4%		94	95.9%		
	Yes	7	4.6%		4	4.1%		
Chronic blood loss anemia	No	151	99.3%		97	99.0%		
	Yes	1	0.7%		1	1.0%		
Leukemia	No	152	100.0%		97	99.0%		
	Yes	0	0.0%		1	1.0%		
Lymphoma	No	150	98.7%		96	98.0%		
	Yes	2	1.3%		2	2.0%		
Metastatic cancer	No	151	99.3%		97	99.0%		
	Yes	1	0.7%		1	1.0%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

		Palliative Care Consult						
		No			Yes			*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
Solid tumor w/o metastasis,insitu	No	152	100%		98	100%		
	Yes	0	0.0%		0	0.0%		
Solid tumor w/o mets, malignant	No	149	98.0%		96	98.0%		
	Yes	3	2.0%		2	2.0%		
Cerebrovascular disease - POA	No	148	97.4%		95	96.9%		
	Yes	4	2.6%		3	3.1%		
Cerebrovascular disease - seq	No	152	100%		96	98.0%		
	Yes	0	0.0%		2	2.0%		
Cerebrovascular dz - paralysis	No	151	99.3%*		91	92.9%		.014
	Yes	1	0.7%		7	7.1%*		.014
Congestive heart failure	No	16	10.5%		8	8.2%		
	Yes	136	89.5%		90	91.8%		
CHF w HTN, complicated	No	42	27.6%		18	18.4%		
	Yes	110	72.4%		80	81.6%		
CHF w HTN, w renal failure	No	144	94.7%		91	92.9%		
	Yes	8	5.3%		7	7.1%		
Coagulopathy	No	143	94.1%*		83	84.7%		
	Yes	9	5.9%		15	15.3%*		
Dementia	No	142	93.4%		88	89.8%		
	Yes	10	6.6%		10	10.2%		
Depression	No	139	91.4%		84	85.7%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

		Palliative Care Consult						
		No			Yes			*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
	Yes	13	8.6%		14	14.3%		
Diabetes w	No	87	57.2%		58	59.2%		
chronic comp	Yes	65	42.8%		40	40.8%		
Diabetes w/o	No	137	90.1%		88	89.8%		
chronic comp	Yes	15	9.9%		10	10.2%		
Drug abuse	No	145	95.4%		94	95.9%		
	Yes	7	4.6%		4	4.1%		
Drug abuse w	No	152	100.0%		98	100.0%		
psychoses	Yes	0	0.0%		0	0.0%		
Hypertension,	No	132	86.8%		91	92.9%		
complicated	Yes	20	13.2%		7	7.1%		
Hypertension, w	No	151	99.3%		98	100.0%		
renal failure	Yes	1	0.7%		0	0.0%		
Hypertension,	No	124	81.6%		88	89.8%		
uncomplicated	Yes	28	18.4%		10	10.2%		
Liver disease,	No	148	97.4%		92	93.9%		
mild	Yes	4	2.6%		6	6.1%		
Liver disease,	No	151	99.3%		96	98.0%		
mod to severe	Yes	1	0.7%		2	2.0%		
Chronic	No	100	65.8%		54	55.1%		
pulmonary dz	Yes	52	34.2%		44	44.9%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

		Palliative Care Consult						
		No			Yes			*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
Neurological dz affecting mvmt	No	151	99.3%		95	96.9%		
	Yes	1	0.7%		3	3.1%		
Other neuro-logical disorders	No	137	90.1%		85	86.7%		
	Yes	15	9.9%		13	13.3%		
Seizures and epilepsy	No	149	98.0%		96	98.0%		
	Yes	3	2.0%		2	2.0%		
Obesity	No	89	58.6%		56	57.1%		
	Yes	63	41.4%		42	42.9%		
Paralysis	No	151	99.3%		95	96.9%		
	Yes	1	0.7%		3	3.1%		
Peripheral vascular disease	No	139	91.4%		90	91.8%		
	Yes	13	8.6%		8	8.2%		
Psychoses	No	149	98.0%		97	99.0%		
	Yes	3	2.0%		1	1.0%		
Pulmonary circulation dz	No	140	92.1%*		74	75.5%		.000
	Yes	12	7.9%		24	24.5%*		.000
Renal failure, moderate	No	117	77.0%*		64	65.3%		.044
	Yes	35	23.0%		34	34.7%*		.044
Renal failure, severe	No	135	88.8%		84	85.7%		
	Yes	17	11.2%		14	14.3%		
Hypothyroidism	No	131	86.2%		75	76.5%		

[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

Table 5 continued

Demographic Characteristics - Total Un-Matched Study Population

			Palliative Care Consult					
			No			Yes		*p[31]
		Count	Column N %	Mean	Count	Column N %	Mean	
	Yes	21	13.8%		23	23.5%		
Other thyroid	No	151	99.3%		98	100.0%		
disorders	Yes	1	0.7%		0	0.0%		
Peptic ulcer	No	148	97.4%		96	98.0%		
with bleeding	Yes	4	2.6%		2	2.0%		
Valvular disease	No	121	79.6%*		60	61.2%		.002
	Yes	31	20.4%		38	38.8%*		.002
Weight loss	No	146	96.1%*		82	83.7%		.001
	Yes	6	3.9%		16	16.3%*		.001

These statistically significant population differences are likely to confound the outcome of interest; thus, it is important to create cohorts that are matched on their likelihood or propensity to receive a palliative care consult.

Propensity-Matching. The population cohort was matched on propensity or the likelihood that two individuals who did and did not receive HFPC consult were otherwise similarly matched on other markers of acute illness severity (lab values and vital signs), prevention (HF guideline adherence), demographic characteristics, and comorbidities. A propensity score was calculated in SPSS version 27 for each case as a regression of all demographic characteristics thus far described (see Figure 1). SPSS version 27 was used to

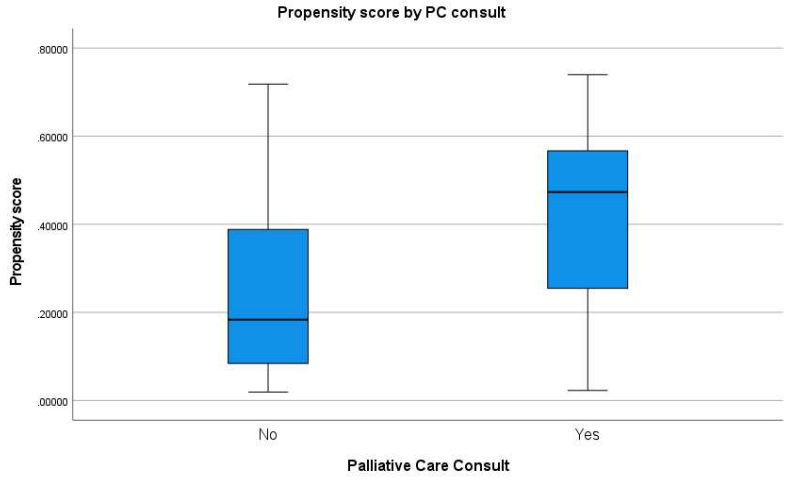
[31] Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction.

perform a regression of all variables collected, including demographic characteristics of age, gender, and insurance; prevention characteristics of adherence to evidence-based HF treatment, including tobacco use, drug therapy, and electrical therapy; index hospitalization severity markers, including selected laboratory values and vital signs present on arrival, DNR status, hospitalization duration, advanced interventions required, discharge disposition, and comorbidities. This regression analysis generated a propensity score that enabled matching of the HFPC and non-HFPC cohorts. The propensity score was then used as a continuous variable to match patients in the non-HFPC consult cohort. Multiple non-HFPC consult patients could be matched to HFPC consult patients with similar characteristics, preserving as much of the data as possible.

At the extremes of scoring, there were a sizable number of patients (n =102) that could not be matched to similar peers in the non-HFPC consult cohort because their score was so low (indicating minimal severity markers) that no HFPC consult was a certainty. Likewise, at the other end of the spectrum, there was a sizable (n =102) number of patients who could not be matched to a similar peer in the non-HFPC consult cohort because their score was so high (indicating numerous severity markers), predicting a certain likelihood of HFPC consult. Thus, propensity matching helped to achieve a more homogeneous population with less variability, ensuring a greater likelihood of observing an accurate and valid assessment of the outcome of interest.

Figure 1

Propensity Score by HFPC Consult



Demographics - Propensity-Matched Cohort. The resulting matched cohort (n =132) is more homogeneous, and both HFPC and non-HFPC cohorts are equivalently matched on demographic characteristics (see Table 4). One hundred and two patients were eliminated as unmatched, which is a significant loss of data but reflects the extremes of propensity scoring. Those at the extremes did not exhibit sufficient variability to contribute to a meaningful answer in the final analysis. (For example, all patients that did not match at the low end of propensity had no palliative care consult, while all patients that did not match at the high end of propensity scoring had a palliative care consult. Chi-square testing of the total population demographic characteristics demonstrated statistically significant differences between the population receiving HFPC consult and the population not receiving HFPC consult p <.0001 prior to matching and p =.077 after matching (see Appendix 10). Likewise, after matching, the range of propensity scores was minimized, and standard deviations were likewise minimized compared to the total population cohort, creating a more homogeneous population and limiting the ability of extreme values to affect the mean.

Table 6

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Age cohort	< 55	23	24.0%	7	19.4%	10	21.7%	9	16.1%
	55-75	40	41.7%	14	38.9%	25	54.3%	20	35.7%
	75+	33	34.4%	15	41.7%	11	23.9%	27	48.2%
Gender	Female	46	47.9%	17	47.2%	21	45.7%	36	64.3%
	Male	50	52.1%	19	52.8%	25	54.3%	20	35.7%
Do Not Resuscitate	.	95	99.0%	34	94.4%	44	95.7%	46	82.1%
	DNR	1	1.0%	2	5.6%	2	4.3%	10	17.9%
Primary Insurance	Commercial	67	69.8%	21	58.3%	29	63.0%	31	55.4%
	Medicaid					6	13.0%		
	Medicare	29	30.2%	15	41.7%	11	23.9%	25	44.6%
Ejection Fraction cohort	.25 Reduced	25	26.0%	10	27.8%	10	21.7%	14	25.0%
	.25-.50 Borderli	35	36.5%	12	33.3%	21	45.7%	16	28.6%
	.50+ Preserved	36	37.5%	14	38.9%	15	32.6%	26	46.4%
AICD or CRT-D Implant	No	70	72.9%	25	69.4%	34	73.9%	43	76.8%
	Yes	26	27.1%	11	30.6%	12	26.1%	13	23.2%
Guideline Adherence	No	41	42.7%	15	41.7%	18	39.1%	40	71.4%
	Yes	55	57.3%	21	58.3%	28	60.9%	16	28.6%
Hospitalization duration	Admission	37	38.5%	14	38.9%	16	34.8%	20	35.7%
	Observation	33	34.4%	11	30.6%	21	45.7%	7	12.5%

[32] No statistically significant differences

[33] Unmatched demographics reflect those at the extremes of the propensity scoring scale such that matching was not feasible. As such it is not appropriate to test population statistically significant differences as they are by definition at opposite extremes.

Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Discharge disposition	Prolonged	26	27.1%	11	30.6%	9	19.6%	29	51.8%
	Home – 01	58	60.4%	20	55.6%	35	76.1%	13	23.2%
	Home w Services	21	21.9%	6	16.7%	6	13.0%	15	26.8%
	Hospice – Home							3	5.4%
	Hospice – Facility							7	12.5%
	Inpt Rehab Facility	1	1.0%					2	3.6%
	LTC Hospital	2	2.1%	1	2.8%			1	1.8%
	Short Term Inpatient					1	2.2%	1	1.8%
	SNF -Skilled Nurse	14	14.6%	9	25.0%	4	8.7%	14	25.0%
BP	Hypertension	59	61.5%	22	61.1%	23	50.0%	35	62.5%
	Hypotension							2	3.6%
	Normal	37	38.5%	14	38.9%	23	50.0%	19	33.9%
HR.	Normal	71	74.0%	26	72.2%	30	65.2%	36	64.3%
	Bradycardia	2	2.1%	1	2.8%	6	13.0%	2	3.6%
	Tachycardia	23	24.0%	9	25.0%	10	21.7%	18	32.1%

[32] No statistically significant differences

[33] Unmatched demographics reflect those at the extremes of the propensity scoring scale such that matching was not feasible. As such it is not appropriate to test population statistically significant differences as they are by definition at opposite extremes.

Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Na	Hypernatremia	4	4.2%	1	2.8%			2	3.6%
	Hyponatremia	13	13.5%	6	16.7%	12	26.1%	9	16.1%
	Normal	79	82.3%	29	80.6%	34	73.9%	45	80.4%
BUN/Cr	Low	10	10.4%	3	8.3%	8	17.4%	4	7.1%
	Normal	53	55.2%	20	55.6%	25	54.3%	33	58.9%
	Renal compromise	33	34.4%	13	36.1%	13	28.3%	19	33.9%
Cr	Abnormal – High	14	14.6%	6	16.7%	10	21.7%	6	10.7%
	Elevated	25	26.0%	9	25.0%	10	21.7%	28	50.0%
	Normal	57	59.4%	21	58.3%	26	56.5%	22	39.3%
Hgb	Anemia	52	54.2%	21	58.3%	24	52.2%	32	57.1%
	Normal	44	45.8%	15	41.7%	22	47.8%	24	42.9%
Hgb A1C	Normal	12	38.7%	5	50.0%	6	40.0%	13	68.4%
	Poor Control	9	29.0%	5	50.0%	7	46.7%	6	31.6%
	Very Poor Control	10	32.3%			2	13.3%		
Pressors required	No	94	97.9%	36	100%	42	91.3%	53	94.6%
	Yes	2	2.1%			4	8.7%	3	5.4%
Intra Aortic Balloon Pump	No	96	100%	36	100%	46	100%	55	98.2%

[32] No statistically significant differences

[33] Unmatched demographics reflect those at the extremes of the propensity scoring scale such that matching was not feasible. As such it is not appropriate to test population statistically significant differences as they are by definition at opposite extremes.

Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
	Yes							1	1.8%
Tobacco Use	Cognitive Deficits								
	Never	53	55.2%	18	50.0%	25	54.3%	36	64.3%
	Last Tobacco Use <30d	13	13.5%	4	11.1%	9	19.6%	6	10.7%
	Last Tobacco Use >1yr	27	28.1%	13	36.1%	8	17.4%	9	16.1%
	Last Tobacco Use >30d <1yr	2	2.1%	1	2.8%	2	4.3%	3	5.4%
	Unable to answer	1	1.0%			2	4.3%	2	3.6%
AIDS	No	96	100%	36	100%	46	100%	54	96.4%
	Yes							2	3.6%
Alcohol abuse	No	95	99.0%	36	100%	46	100%	55	98.2%
	Yes	1	1.0%					1	1.8%
Alcohol abuse w/ mild liver disease	No	96	100%	36	100%	46	100%	56	100%
	Yes								
Deficiency Anemias	No	72	75.0%	26	72.2%	37	80.4%	37	66.1%
	Yes	24	25.0%	10	27.8%	9	19.6%	19	33.9%

[32] No statistically significant differences

[33] Unmatched demographics reflect those at the extremes of the propensity scoring scale such that matching was not feasible. As such it is not appropriate to test population statistically significant differences as they are by definition at opposite extremes.

Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Arthropathies	No	90	93.8%	35	97.2%	45	97.8%	53	94.6%
	Yes	6	6.3%	1	2.8%	1	2.2%	3	5.4%
Chronic blood loss anemia	No	96	100%	36	100%	45	97.8%	55	98.2%
	Yes					1	2.2%	1	1.8%
Leukemia	No	96	100%	36	100%	46	100%	55	98.2%
	Yes							1	1.8%
Lymphoma	No	94	97.9%	35	97.2%	46	100%	56	100%
	Yes	2	2.1%	1	2.8%				
Metastatic cancer	No	95	99.0%	35	97.2%	46	100%	56	100%
	Yes	1	1.0%	1	2.8%				
Solid tumor w/o metastasis, in situ	No	96	100%	36	100%	46	100%	56	100%
	Yes								
Solid tumor w/o mets, malignant	No	95	99.0%	35	97.2%	44	95.7%	55	98.2%
	Yes	1	1.0%	1	2.8%	2	4.3%	1	1.8%
Cerebrovascular disease - POA	No	94	97.9%	35	97.2%	45	97.8%	54	96.4%
	Yes	2	2.1%	1	2.8%	1	2.2%	2	3.6%
Cerebrovascular disease - seq	No	96	100%	36	100%	46	100%	55	98.2%
	Yes							1	1.8%
Cerebrovascular disease -paralysis	No	95	99.0%	36	100%	46	100%	50	89.3%

[32] No statistically significant differences

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Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
	Yes	1	1.0%					6	10.7%
Congestive heart failure	No	9	9.4%	4	11.1%	5	10.9%	3	5.4%
	Yes	87	90.6%	32	88.9%	41	89.1%	53	94.6%
CHF with hypertension, complicated	No	21	21.9%	6	16.7%	16	34.8%	8	14.3%
	Yes	75	78.1%	30	83.3%	30	65.2%	48	85.7%
CHF with hypertension w renal failure, sev	No	91	94.8%	34	94.4%	45	97.8%	54	96.4%
	Yes	5	5.2%	2	5.6%	1	2.2%	2	3.6%
Coagulopathy	No	90	93.8%	35	97.2%	44	95.7%	42	75.0%
	Yes	6	6.3%	1	2.8%	2	4.3%	14	25.0%
Dementia	No	89	92.7%	32	88.9%	43	93.5%	51	91.1%
	Yes	7	7.3%	4	11.1%	3	6.5%	5	8.9%
Depression	No	87	90.6%	32	88.9%	42	91.3%	49	87.5%
	Yes	9	9.4%	4	11.1%	4	8.7%	7	12.5%
Diabetes with chronic comp	No	55	57.3%	22	61.1%	24	52.2%	33	58.9%
	Yes	41	42.7%	14	38.9%	22	47.8%	23	41.1%
Diabetes w/o chronic comp	No	83	86.5%	31	86.1%	46	100%	51	91.1%
	Yes	13	13.5%	5	13.9%			5	8.9%
Drug abuse	No	91	94.8%	34	94.4%	45	97.8%	54	96.4%

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Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
	Yes	5	5.2%	2	5.6%	1	2.2%	2	3.6%
Drug abuse with psychoses	No	96	100%	36	100%	46	100%	56	100%
	Yes								
Hypertension, complicated	No	85	88.5%	33	91.7%	38	82.6%	53	94.6%
	Yes	11	11.5%	3	8.3%	8	17.4%	3	5.4%
Hypertension, w/ renal failure, sev	No	96	100%	36	100%	45	97.8%	56	100%
	Yes					1	2.2%		
Hypertension, uncomplicated	No	78	81.3%	31	86.1%	39	84.8%	51	91.1%
	Yes	18	18.8%	5	13.9%	7	15.2%	5	8.9%
Liver disease, mild	No	95	99.0%	36	100%	44	95.7%	50	89.3%
	Yes	1	1.0%			2	4.3%	6	10.7%
Liver disease, mod to sev	No	95	99.0%	36	100%	46	100%	54	96.4%
	Yes	1	1.0%					2	3.6%
Chronic pulmonary dz	No	59	61.5%	22	61.1%	34	73.9%	29	51.8%
	Yes	37	38.5%	14	38.9%	12	26.1%	27	48.2%
Neurological dz affecting mvmt	No	95	99.0%	35	97.2%	46	100%	54	96.4%
	Yes	1	1.0%	1	2.8%			2	3.6%
Other neuro-logical disorders	No	85	88.5%	32	88.9%	44	95.7%	47	83.9%
	Yes	11	11.5%	4	11.1%	2	4.3%	9	16.1%

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Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Seizures and epilepsy	No	94	97.9%	34	94.4%	45	97.8%	56	100%
	Yes	2	2.1%	2	5.6%	1	2.2%		
Obesity	No	53	55.2%	19	52.8%	28	60.9%	34	60.7%
	Yes	43	44.8%	17	47.2%	18	39.1%	22	39.3%
Paralysis	No	95	99.0%	35	97.2%	46	100%	54	96.4%
	Yes	1	1.0%	1	2.8%			2	3.6%
Peripheral vascular disease	No	87	90.6%	33	91.7%	43	93.5%	52	92.9%
	Yes	9	9.4%	3	8.3%	3	6.5%	4	7.1%
Psychoses	No	94	97.9%	35	97.2%	45	97.8%	56	100%
	Yes	2	2.1%	1	2.8%	1	2.2%		
Pulmonary circulation dz	No	84	87.5%	33	91.7%	46	100%	36	64.3%
	Yes	12	12.5%	3	8.3%			20	35.7%
Renal failure, moderate	No	73	76.0%	25	69.4%	35	76.1%	35	62.5%
	Yes	23	24.0%	11	30.6%	11	23.9%	21	37.5%
Renal failure, severe	No	86	89.6%	32	88.9%	42	91.3%	49	87.5%
	Yes	10	10.4%	4	11.1%	4	8.7%	7	12.5%
Hypothyroidism	No	83	86.5%	32	88.9%	39	84.8%	39	69.6%
	Yes	13	13.5%	4	11.1%	7	15.2%	17	30.4%

[32] No statistically significant differences

[33] Unmatched demographics reflect those at the extremes of the propensity scoring scale such that matching was not feasible. As such it is not appropriate to test population statistically significant differences as they are by definition at opposite extremes.

Table 6 continued

Demographic Characteristics of Propensity-Matched Cohort

		Cohort Demographics							
		Matched [32](132)				Unmatched [33](102)			
		Palliative Care Consult				Palliative Care Consult			
		No		Yes		No		Yes	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Other thyroid disorders	No	96	100%	36	100%	45	97.8%	56	100%
	Yes					1	2.2%		
Peptic ulcer with bleeding	No	92	95.8%	35	97.2%	46	100%	55	98.2%
	Yes	4	4.2%	1	2.8%			1	1.8%
Valvular disease	No	72	75.0%	25	69.4%	41	89.1%	31	55.4%
	Yes	24	25.0%	11	30.6%	5	10.9%	25	44.6%
Weight loss	No	91	94.8%	34	94.4%	45	97.8%	43	76.8%
	Yes	5	5.2%	2	5.6%	1	2.2%	13	23.2%

Table 6 demonstrates that the resulting propensity-matched cohorts exhibit strong demographic similarities, and no statistically significant differences remain. The residual unmatched cohort included those that did not match into the propensity-matched cohort and illustrate characteristics of the outliers that were redacted during the process of propensity-matching from the final propensity-matched cohort used in the final analysis. Importantly, ANOVA analysis of the total population and matched cohorts showed that even after matching,

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statistically significant differences in the mean remain between the HFPC consult x =.25, 95% CI [.21 - 29] and non-HFPC consult x =.42, 95% CI [.35-.49] cohorts (see Table 7).

Further analysis continued based on these findings. If the ANOVA had demonstrated a loss of statistical significance after matching, it would have been interpreted that matching eliminated all sources of difference, and further analysis would have been futile. Likewise, calculation of standardized differences (effect size) of the means before and after matching found a persistently strong effect size of Cohen's *d* =0.86 in the unadjusted model and Cohen's *d* =0.83 in the propensity-matched model, indicating that there is no substantial loss of predictive ability after matching.

Table 7

Comparison of Means and Standardized Difference of Total Study Population vs. Propensity-matched Cohort for Presence/Absence of HFPC Consult

	Palliative Care Consult – No				Palliative Care Consult - Yes				Cohen's d
Propensity score	Mean	95% UCL	95% LCL	SD	Mean	95% UCL	95% LCL	SD	
Total population cohort	.16965	.13712	.20218	.19608	.73815	.67685	.79945	.29600	0.86
Matched cohort	.24879	.20879	.28759	.19444	.41754	.34612	.48896	.21107	0.83

Odds Ratios Predictive of HFPC

While logistic regression was used to answer the primary research question of interest, whether 90-day hospital readmission is affected by HFPC consult after controlling for mortality and severity, it was also part of the a priori analysis plan to further evaluate the important contributing factors to the occurrence of an HFPC consult to gain insight into why a specific outcome was observed. For example, if patients who received HFPC consult were appropriately

targeted. Logistic regression of the total population characteristics produced calculated odds or risk of each individual characteristic to contribute to the overall likelihood of a patient having an HFPC consult (see Table 8). Odds ratio is a measure of association that provides an indication of the effect size existing between the predicting factor and the outcome of interest.

Table 8

Odds Ratios Predicting the Likelihood of HFPC Consult

Demographic Categories	Characteristics	Odds Ratio
Age cohort	<55	
	55-75	.180*
	75+	.402
Gender	Gender (Female)	2.943
Do Not Resuscitate	Do Not Resuscitate	2.574
Primary insurance	Commercial	
	Medicaid	.000
	Medicare	3.670*
Ejection Fraction cohort	50%+ Preserved	
	25% Reduced	3.035
	25-50% Borderline	.995
AICD/CRT-D	AICD or CRT-D Implant (Yes)	3.127
Guideline Adherence	Guideline Adherence (No)	2.475
Hospitalization duration	Admission	
	Observation	1.004
	Prolonged	.611
Discharge disposition	Home	
	Home w/ Home Health	5.342*
	Hospice	4877036073.909
	Inpatient Rehabilitation Facility	115.070
	Long Term Care	2.635

Table 8 continued

Odds Ratios Predicting the Likelihood of HFPC Consult

Demographic Categories	Characteristics	Odds Ratio
	Short Term Gen Hospital	.000
	Skilled Nursing Facility	13.418*
Blood Pressure on arrival	Normal	
	Hypertensive	3.672*
	Hypotensive	74028849642.421
HR on arrival	Normal	
	Bradycardic	.043
	Tachycardic	3.569
Na on arrival	Normal	
	Hypernatremic	2.635
	Hyponatremic	.358
BUN/Cr on arrival	Low	
	Normal	3.639
	Renal compromise	2.449
Cr on arrival	Normal	
	Abnormal	.733
	Elevated	7.509*
Hgb on arrival	Anemia	.550
Pressors required	Pressors required (Yes)	.506
IntraAortic Balloon Pump	Intra Aortic Balloon Pump (Yes)	506772158989469180
Tobacco Use	Denies	
	Tobacco use < 30 d	.158
	Tobacco use > 1 yr	.966
	Tobacco Use >30d <1yr	.148
	Unable to answer	.018
Comorbidities coded	AIDS	376707060855.6
	Alcohol abuse	7.5

Table 8 continued

Odds Ratios Predicting the Likelihood of HFPC Consult

Demographic Categories	Characteristics	Odds Ratio
	Deficiency Anemias	1.7
	Arthropathies	.027*
	Chronic blood loss anemia	6.9
	Leukemia	12130545869000848.0
	Lymphoma	.028
	Metastatic cancer	806628941303.5
	Solid tumor w/o mets, malignant	.000
	Cerebrovascular disease - POA	9.6
	Cerebrovascular dz - sequelae	487343389861.8
	Cerebrovascular dz - paralysis	10.4
	Congestive heart failure	.047*
	CHF with HTN, complicated	4.4
	CHF with HTN w renal failure	66.8*
	Coagulopathy	7.7
	Dementia	.6
	Depression	1.1
	Diabetes w/ chronic complications	.3
	Diabetes w/o chronic complications	19.0*
	Drug abuse	3.1
	Hypertension, complicated	.2
	Hypertension, comp with renal failure, severe	.000
	Hypertension, uncomplicated	.4
	Liver disease, mild	9.3
	Liver disease, moderate to severe	.2
	Chronic pulmonary disease	10.6*

Table 8 continued

Odds Ratios Predicting the Likelihood of HFPC Consult

Demographic Categories	Characteristics	Odds Ratio
	Neurological disorders affecting movement	.3
	Other neurological disorders	.6
	Seizures and epilepsy	8.2
	Obesity	2.8
	Paralysis	16.8
	Peripheral vascular disease	.75
	Psychoses	.91
	Pulmonary circulation disease	8.9
	Renal failure, moderate	1.9
	Renal failure, severe	1.8
	Hypothyroidism	1.0
	Other thyroid disorders	.22
	Peptic ulcer with bleeding	.2
	Valvular disease	4.2*
	Weight loss	6.8

Note. Statistically significant factors $p \leq .05$ are signified by *
*$p \leq .05$

This sub-analysis demonstrates the underlying factors that are statistically significantly associated with HFPC consult, a key independent variable in the primary research question of interest, whether 90-day hospital readmission is affected by HFPC consult after controlling for 90-day mortality and severity (propensity score). This sub-analysis provides context and clarity for interpreting the meaning of the primary study findings. From the primary analysis, it was shown that HFPC consultation is negatively associated with hospital readmission after controlling for mortality and severity. This sub-analysis likewise provides a contextual

understanding of the individual characteristics that are likely to produce an HFPC consult during an inpatient hospitalization. It includes age 55-75, Medicare insurance, discharge with home health services and discharge to SNF, hypertensive on admission, and elevated Cr on admission. Comorbidities likely to result in an HFPC consult include arthropathies, HF, HF with renal failure, Diabetes without chronic complications, COPD, and valvular disease.

Survival Analysis

A further a priori planned sub-analysis that also provided additional context and clarity to the primary study findings is an analysis of time to hospital readmission which was used in the primary analysis as a binary outcome of 90-day hospital readmission (Y/N). However, hospital readmission can also be viewed as a continuous variable. The a priori plan to include survival analysis in the data analysis was to take full advantage of the data available on the temporal patterns of readmission that occur within the 90-day window of hospital readmission. Among the total unmatched population, the average time to hospital readmission for patients with no HFPC consult was 5.6 weeks, and 3.6 weeks for patients with an HFPC consult (see Table 9). This finding further describes the results in the preliminary logistic regression that noted the negative association between HFPC and no hospital readmission; as HFPC events increased, hospital readmission events were more frequent.

Table 9

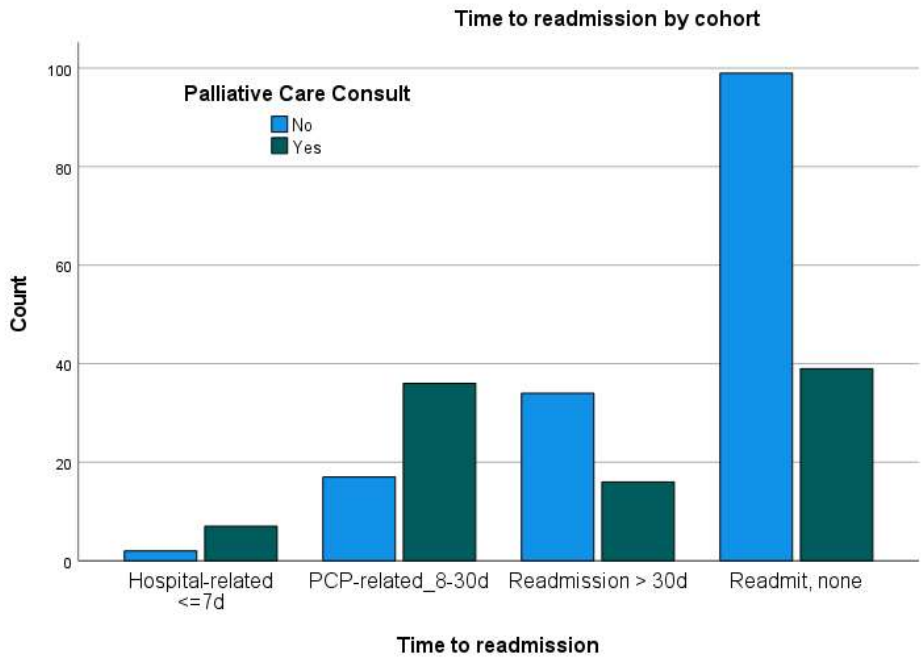
Mean Time to Readmission, Weeks

Palliative Care Consult	Mean	N	Std. Deviation
No	5.626	53	3.1240
Yes	3.588	60	2.8264
Total	4.544	113	3.1278

Hospital-related admissions were those that occurred within seven days of hospital discharge and were directly related to the hospitalization (Chin et al., 2016). HFPC-related admissions were those that occurred from 8-30 days post index hospitalization and account for more predominantly HFPC-related factors of patient management (Chin et al., 2016). While the majority of patients with no HFPC consult did not require readmission, a more flattened distribution of patients who received an HFPC consult experienced a readmission within the 90-day observation period, perhaps indicating a more significant level of morbidity and complications requiring hospital readmission than the no HFPC consult cohort (see Figure 2).

Figure 2

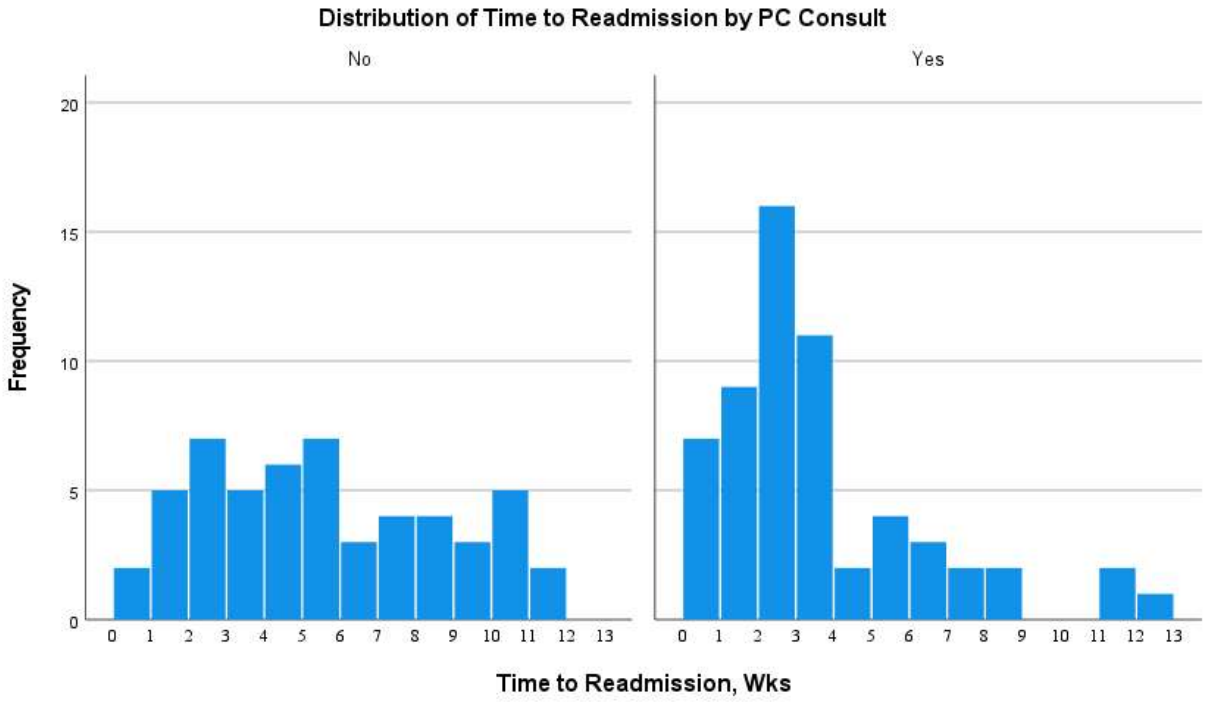
Time to Hospital Readmission Stratified by Presence/Absence of HFPC Consult



Likewise, a graphical depiction of the time to readmission (see Figure 3), stratified by HFPC consult for the entire study population, illustrates a strong tendency for earlier hospital readmission if the patient had an HFPC consult compared to the cohort that did not have an HFPC consult.

Figure 3

Distribution of Time to Readmission by HFPC Consult



Patterns of hospital readmission stratified by cohorts that had an HFPC consult/no HFPC consult added additional clarity and context to the primary research question of interest that found a strong statistically significant relationship between 90-day hospital readmission and HFPC consult. Time to readmission happened more frequently in patients who have an HFPC consult. Readmissions occurred earlier in the post-discharge period and were strongly skewed to the immediate 30-day post-discharge period.

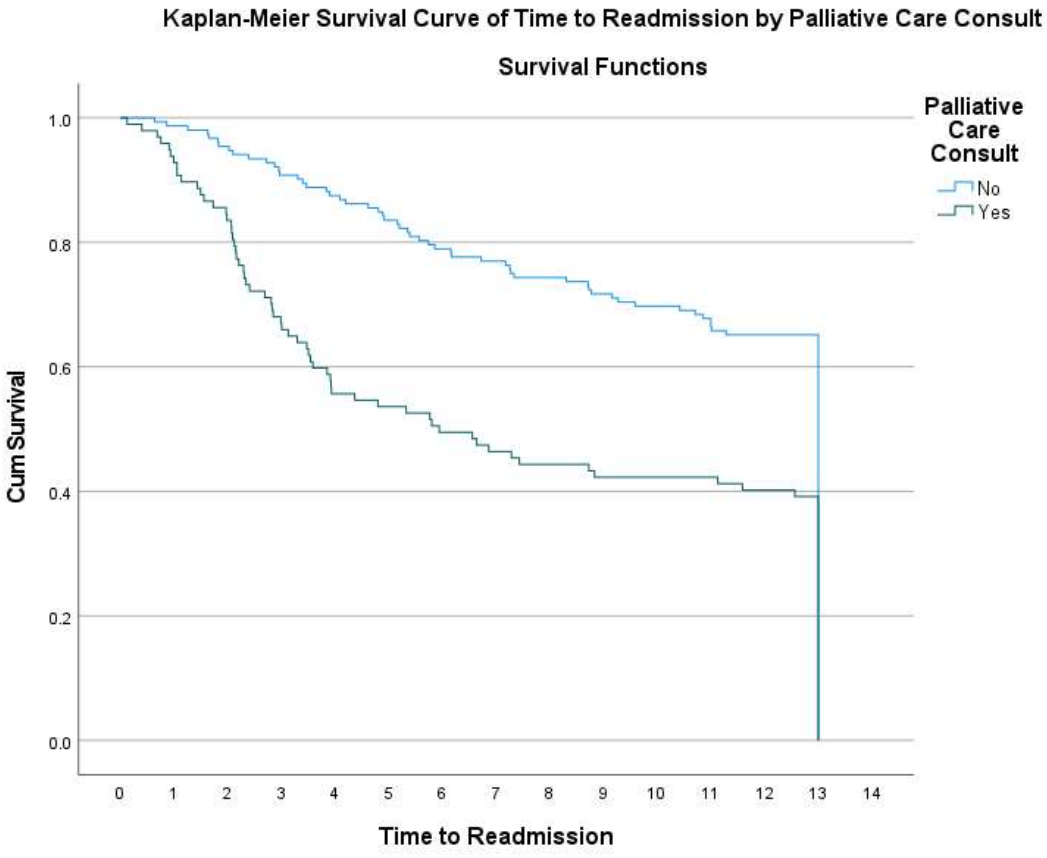
Kaplan-Meier Survival Curve of Time to Readmission

To gain further insight into the patterns of hospital readmission, survival analysis was chosen for this sub-analysis because it enables statistical analysis of time to event data, in this case, time to hospital readmission, stratified by cohorts, presence/absence of HFPC consult. The primary research question of interest demonstrated that HFPC consult was statistically significantly associated with 90-day hospital readmission after controlling for 90-day mortality

and severity (propensity-score). Survival analysis provides additional insight into the differential burden of hospital readmission borne by the cohorts and illustrates the difficulties this population experiences with avoiding 90-day hospital readmission. A survival curve of time to readmission by HFPC consult was constructed for the entire study population (see Figure 4) and found statistically significant differences in the time to hospital readmission for the cohorts with Log Rank (Mantel-Cox) tests significant at <.0001, and Breslow (Generalized Wilcoxon) tests significant at <.0001.

Figure 4

Kaplan-Meier Survival Curve of Time to Readmission by HFPC Consult

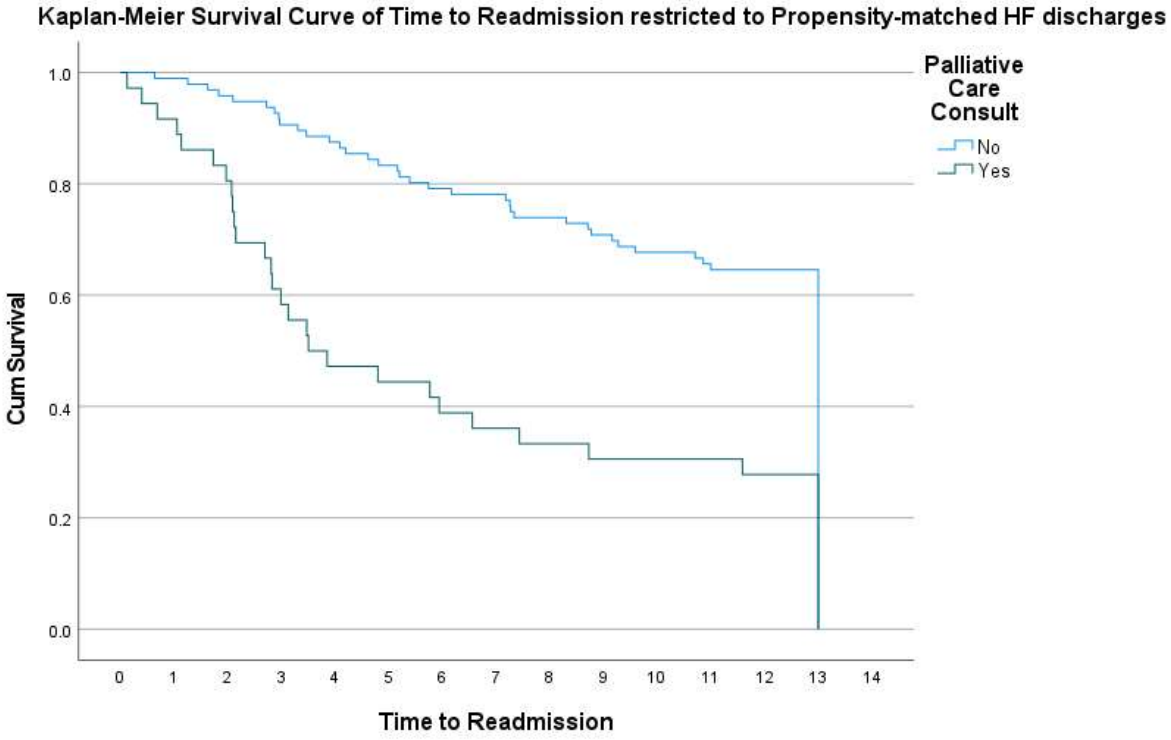


In the second survival curve analysis, results were even more profound with the population restricted to the propensity-matched cohorts used in the primary logistic regression analysis of the primary research question of interest. Comparing presence/absence of HFPC

consult, the difference in the two curves was even greater and remained statistically significant by Log Rank (Mantel-Cox) tests significant at <.0001 and Breslow (Generalized Wilcoxon) tests significant at <.0001 (see Figure 5).

Figure 5

Kaplan-Meier Survival Curve of Time to Readmission Restricted to Propensity-matched HF Discharges



This survival analysis demonstrated that <30% of HF patients who have an HFPC consult are unable to avoid hospital readmission for >90 days. Over 50% of HF patients who have an HFPC consult experience a hospital readmission within 30 days of discharge. Over 75% of HF patients who have an HFPC consult will have a hospital readmission within 90 days of discharge. Among patients who do not have an HFPC consult, >60% of patients will not require a hospital readmission within the first 90 days post-discharge.

Findings

The data analysis of this investigation yielded a breadth of findings. Compilation of the final dataset identified an average of 83 patients per month with a primary diagnosis of HF. Data abstraction was facilitated by a robust data architecture that enabled an automated abstraction of a broad array of data variables. The need to re-sort, re-order and transform data variables from multiple raw data files to integrate them into a single dataset remains. For example, laboratory values are output listwise. For example, there is a 'case' for every lab value that requires re-ordering such that all values appear as an individual variable for each case. Likewise, all coded comorbidities are output listwise and require selection of the comorbidities of interest before the data can be re-ordered and incorporated into the final dataset.

Lastly, while evidence has previously suggested that the most valid and reliable method to abstract HFPC consultations was found to be an abstraction of the coded PC consult, it is important to note that this coded or 'billed' visit may not appear in an individual hospital database if that hospital does not directly bill for the service. Dependent on state regulations, third-party billing may allow the physician to bill the patient/insurance directly; thus, those codes do not appear on an abstraction of hospital administrative data. Also, the ease with which highly customizable data can be abstracted within the existing data architecture is dependent on whether a field is standardized and abstractable.

In this investigation, zero-coded PC visits were abstracted. Abstraction of consults was likewise unfeasible because of the absence of standardized data abstraction fields. Within this data architecture, there were no standardized naming conventions for consults; thus, this individualization of the consult name meant that the HFPC consult events were not abstractable. This finding is important as an insight for future investigations to be aware of the subtleties of

individual hospital data architecture systems that may limit access to the occurrence of the event and underestimate the event occurrence. It is further offered as a caution to investigations that primarily rely on administrative coding data to assess the efficacy of HFPC consult interventions.

Transformation of data once incorporated into the final dataset was necessary to enable clinically meaningful and interpretable data. While continuous data was available for laboratory and vital sign data, the meaning or clinical applicability of a single unit change in blood pressure was less important than the meaning and clinical applicability of a comparison of strata of blood pressure measurements. Comparison of hypertensive or hypotensive values to normal values was much more clinically meaningful and applicable than comparison of a systolic blood pressure value that varied from 99 to 100. Likewise, directionality may be a clinically important element but may not be appropriate for a parameter that exhibits reverse or bi-directionality. For example, Cr could be evaluated with a continuous measure as a low creatinine is ‘bad,’ and a high Cr is ‘bad.’ Conversely, with BP, low and high values are ‘bad,’ while middle values are ‘normal. Similarly, EF percentages, with high values are ‘good,’ and low values are ‘bad.’ This insight is offered as an important finding and caution that it is important not only to use the data that is available (continuous) and statistically valid but to maintain awareness that transformation or stratification may be preferred to ensure those resulting findings are clinically meaningful.

The CONSORT study summary format is a helpful tool to summarize important elements of a study investigation to convey important elements of the study construct. The construct is helpful to the reader and reviewers to understand the critical elements of the investigation. Logistic regression to evaluate the primary research question of interest, whether there was a statistically significant association between the dependent variable of 90-day hospital readmission and the independent variables of 90-day mortality, HFPC consult and propensity

score (severity). In this model, no HFPC-consult was statistically significantly associated with no 90-day hospital readmission, *B* =1.468, *p* <.001, *OR* 4.3, 95% CI [1.8-10.6]. Likewise, increased mortality was associated with no 90-day hospital readmission, although it was not statistically significant, *B* =.482, *p* =.36 (*OR* 1.8). Decreased severity was also associated with no 90-day hospital readmission *B* =-0.631, *p* =.504 (*OR* 1.6), but was not statistically significant (see Table 3).

These results reveal that avoidance of 90-day hospital readmission is best achieved by having no criteria for the performance of an HFPC-consult, experiencing a mortality event, or having fewer comorbidities. All of these elements: (1) having no criteria for the performance of an HFPC-consult, (2) experiencing a mortality event, or (3) having fewer comorbidities are all largely out of the control of any individual patient. Thus, while HFPC may be an important aspect of continuity of care and care planning for the HF patient, it is not a valid or effective method for reducing 90-day hospital readmissions. Patients with an acute decompensation of their HF, evidenced by abnormal key lab indicators on arrival or patients with numerous comorbidities or approaching end-of-life, are more likely to be referred for HFPC consult. In this investigation, HFPC consult was predicted by and served as a proxy for the HF patient who has an acute decompensation with abnormal lab values on admission, with numerous comorbidities, or approaching end-of-life. HFPC consultation has many values in the care and management of the HF patient. However, reducing 90-day hospital readmission is not an achievable goal. Conversely, HFPC consult should serve as a proxy signal to expect the increased frequency of admissions in a population with high morbidity approaching end-of-life.

To evaluate the robustness of the model, the non-propensity matched model was analyzed and demonstrated similar statistically significant associations between no 90-day hospital

readmission and no HFPC consult B =1.442, p <.001 (*OR* 4.2; see Table 4). Likewise, no 90-day hospital readmission was associated with a non-statistically significant .611, p =.115 increase in post-discharge mortality (*OR* 1.8) after controlling for HFPC consultation and severity. Lastly, 90-day hospital readmission was associated with a non-statistically significant .0.46 increase in severity (propensity score; *OR* 1.6) after controlling for mortality and HFPC consult. It is congruent that avoidance of 90-day hospital readmission would be associated with no HFPC consult (less sick) and increased mortality (patients died); however, it is incongruent that increased severity would be associated with no 90-day readmission and perhaps reflect the influence of the inclusion of outliers redacted in the propensity-matched model.

An important aspect of any statistical analysis is an assessment of underlying demographic differences that may exist and potentially confound the results of the planned analysis. The demographic characteristics of the total study population, n =234, after exclusion of ineligible subjects, clearly illustrated important and statistically significant differences in the study cohort that received an HFPC consult compared to the cohort that did not (see Table 5). There were statistically significant differences in age, DNR status, primary insurance, secondary insurance, adherence to evidence-based guidelines for the treatment of HF, specifically ACE/ARB use, duration of hospitalization, discharge disposition, 90-day readmission, mortality, and renal compromise on admission. There were further statistically significant differences in comorbidities, including deficiency anemias, paralysis as a sequela to cerebrovascular disease, pulmonary circulation disease, renal failure, valvular heart disease, and weight loss.

Propensity-matching was planned during the initial study plan to ensure comparable study cohorts of individuals who did and did not have an HFPC consult. Propensity-matching calculates a score that is derived from a linear regression of characteristics found in the original

demographic characteristics list. When incorporated in the final analysis, the propensity score ensures that comparisons are made between subjects who are a best match on all characteristics with the exception of the outcome of interest, HFPC consultation. Thus, the investigator can be assured that a comparison is being made between homogeneous populations and not being influenced by outliers.

The resulting propensity-matched cohort, n =132, demonstrated improved homogeneity with the absence of statistical significance for any individual characteristic (see Table 6). However, while propensity-matching achieved population homogeneity, it did not eradicate statistically significant differences between the HFPC consult and non-HFPC consult cohort with a mean propensity score of 0.25, 95% CI [0.21-0.29] in the no HFPC consult cohort, and the HFPC consult cohort demonstrating a mean of 0.42, 95% CI [0.35 - 0.49] (see Table 7). Likewise, a comparison of the standardized difference in the un-propensity matched cohort and propensity-matched cohort with Cohen's *d* indicates a persistently strong effect size in both models, suggesting that there is no loss of the predictive ability of the model after matching (see Table 7). Cohen's *d* measures the magnitude of the relationship between the variable measured (propensity score) and the outcome of interest (HFPC consult).

To further investigate the relationship between HFPC consult and hospital readmission as part of the a priori analysis plan, a logistic regression of the model variables was performed to obtain the associated *OR* or risk of individual demographic characteristics to contribute to the occurrence of a palliative care consult (see Table 8). Statistically significant and clinically important associations were found with these characteristics: recipient having Medicare insurance (*OR* 3.7), discharge home with home health (*OR* 5.3), discharge to skilled nursing facility (*OR* 13.4), hypertensive on arrival (*OR* 3.7), elevated Cr on arrival (7.5), CHF with

hypertension w/severe renal failure (*OR* 66.8), diabetes without chronic complications (*OR* 19.0), chronic pulmonary disease (*OR* 10.6) and valvular disease (*OR* 4.2). Statistically significant but clinically meaningless associations were found with the age cohort 55-75 (*OR*.18); comorbidities of arthropathies (*OR* .03) and CHF (*OR* .05) were likely attributable to collinearity as by definition, all members of the cohort had a primary discharge diagnosis of HF.

To further evaluate the relationship between HFPC consult and hospital readmission, means were calculated. For the entire cohort that experienced a hospital readmission n =113, the mean time to hospital readmission for patients who had no HFPC consult was 5.6 weeks, while the mean for patients who had an HFPC consult was 3.6 weeks (see Table 9). The pattern of hospital readmissions is likewise significantly different. Patients with an HFPC consult demonstrated earlier hospital readmission, with 88% of subjects realizing a hospital readmission within the first 30 days, compared to just 36% of patients with no HFPC consult. Forty percent of patients in the HFPC consult group had no 90-day readmission, while 75% of patients in the no-HFPC consult cohort had no 90-day hospital readmission (see Figure 4). Figure 5 demonstrates the almost flat curve of readmissions amongst patients with no HFPC consult while the patients with an HFPC consult spiked very early in the first 30-days post-discharge and then tapered to a minimum. Patients with HF targeted for HFPC consult were more likely to experience not only more frequent hospital readmissions but also earlier times to readmission in the post-discharge period, the majority within the first 30 days.

This investigation has fully established that there is a statistically significant difference in 90-day hospital readmission between the cohort of subjects with an HFPC consult versus those with no HFPC consult; thus, it is important to fully appreciate the granularity present within the dataset. Not only is it important to have established the core difference in 90-day hospital

readmissions, but the differential trend in hospital readmission is further appreciated with a survival analysis of time to readmission. The survival analysis of the total study population identified a statistically significant difference between subjects with and without HFPC consult (see Figure 4). The propensity-matched survival analysis identified an even greater magnitude of difference in the curves (see Figure 5). Both analyses were strongly statistically significant by Log Rank (Mantel-Cox) <.0001 and Breslow (Generalized Wilcoxon) <.0001.

An overview of the entire study population demonstrated that <30% of HF patients who have an HFPC consult are unable to avoid hospital readmission for >90 days, >50% of HF patients who have an HFPC consult experienced a hospital readmission within 30 days of discharge, and > 75% of HF patients who have an HFPC consult will have a hospital readmission within 90 days of discharge. This survival analysis conveyed the real disparity in the experience of patients with respect to hospital readmission for subjects with an HFPC consult compared to those with no HFPC consult.

HF patients receiving appropriately targeted HFPC consultation experience earlier and more frequent hospital readmissions, higher mortality, and suffer greater severity of their illness. It is counterproductive to attempt to advocate HFPC to achieve reductions in 90-day hospital readmissions. If anything, this study has established that once appropriately targeted HF patients have been referred to HFPC, plans should be implemented to accommodate an expected increased frequency of hospital readmissions and decreased time to readmission with accompanying increased mortality.

Chapter 5: Discussion

Introduction

This section discusses the findings of the study, whether the study has met its specified objectives, the findings in relation to the existing literature, and the strengths, weaknesses, and limitations of this investigation. The implications section discusses the impact of this investigation, contributions to knowledge and professional practice, and the future implications of this research with recommendations for further/future research. Lastly, the chapter provides a discussion of limitations and delimitations.

Outcomes of the logistic regression of the propensity-matched model showed that for every unit reduction in 90-day hospital readmission, there was a statistically significant 1.468 increase in no HFPC consult (reduction in HFPC consult), p =.001. Propensity-matching ensures that comparisons are made between subjects who are a best match on all characteristics with the exception of the outcome of interest. The resulting propensity-matched cohort, n =132, demonstrated improved homogeneity with the absence of statistical significance for any individual characteristic. To further evaluate the relationship between HFPC consult and hospital readmission, means were calculated. For the entire cohort that experienced a hospital readmission n =113, the mean time to hospital readmission for patients who had no HFPC consult was 5.6 weeks, while the mean for patients who had an HFPC consult was 3.6 weeks. Survival analysis of the unmatched population identified statistically significant differences between subjects with and without HFPC consult, p <.001. The propensity-matched survival analysis identified an even greater magnitude of difference in the curves, p < .001. Less than 30% of HF patients who have an HFPC consult will avoid hospital readmission for over 90 days, >50% of HF patients who have an HFPC consult will have a hospital readmission within 30 days

of discharge, and > 75% of HF patients who have an HFPC consult will have a hospital readmission within 90 days of discharge.

Discussion

The investigation set out to evaluate the association of palliative care consultation in the hospital setting with hospital readmissions at 90 days post-discharge with statistical controls for mortality and severity through propensity-matching. Numerous guidelines on ensuring excellence in HF management have established recommendations that palliative care should be a part of the multidisciplinary health care team managing patients with HF. Numerous studies have explored the relationship between palliative care and 30-day hospital readmission to provide support for these recommendations. Some of the studies found that HFPC consult decreased the risk of hospital readmission; others found only an equivocal association, while others found a negative association. Most of these studies were retrospective and relied on administrative datasets to quantify their results. These studies did not assess the relationship of palliative care with 90-day hospital readmission with adequate controls for mortality and severity.

Studies that have assessed mortality associated with palliative have done so primarily with comparisons of pre- and post- HRRP implementation population-based metrics or comparison to severity-adjusted populations. This investigation aimed to not simply compare whether mortality rates are the same in HFPC versus non-HFPC consult groups but to control for mortality and assess the ability of HFPC consult to decrease hospital 90-day readmissions in a defined hospital population that has actively promoted the adoption of HFPC consults in its HF population. The findings of this investigation indicate that in a propensity-matched population, adjusting for mortality, HFPC consultation is positively associated with 90-day hospital readmission. In other words, patients who received an HFPC consult were statistically

significantly more likely to have a readmission within 90 days compared to the propensity-matched cohort that did not have an HFPC consult. As such, an HFPC consult may not be causal for the increased prevalence of 90-day hospital readmissions, as it more than likely reflects a level of morbidity that cannot be quantified by even the most exhaustive measurement of covariates. This investigation included an exhaustive list of covariates, and if the relationship between HFPC consult and 90-day hospital readmission were weak, it would have been eradicated by 'overmatching.' However, this did not occur. Rather, the relationship between HFPC consult and 90-day hospital readmission remained strong and highly statistically significant.

An alternative explanation is that care providers in this institution are highly attuned to the intangible aspects of patient management that predict which individuals are likely to be high utilizers of health system resources and thus selected for an HFPC consult. Thus, selection bias may exist at the provider level, embedded within the individualized care management planning for patients. These study findings may suggest that such high utilizers are being given all the resources that the health system has at its disposal to attempt to meet the patient's needs. Such an aim is intuitively a value-added intervention for the patient. As such, these findings should not suggest that HFPC has no value, but the findings are clear that as a method to decrease 90-day hospital readmission, HFPC consultation is not a valid approach.

The hypothesis of this investigation was that the increased level of resources, education, facilitated decision-making, and future health planning would enable the patient to better understand their symptoms and improve health behaviors through a better understanding of the health system and enable them to seek health care services in less hospital-oriented settings, ultimately decreasing hospital readmissions. While previous studies, primarily based in other

countries with a greater population-focused system of health care, have demonstrated decreased hospital readmissions, at best, equivocal findings in reducing hospital readmission have been found in the United States. This study highlighted those equivocal findings that typically did not incorporate controls for severity or mortality—there, in truth, is no association between HFPC consult and 90-day hospital readmission. Due to the nature of the health care system and its focus on acute care, it may be a plausible alternative that the hospital environment is the best location of care for patients with end-stage HF who suffer from a significant level of morbidity, acute decompensation, and limited expertise and find it difficult to access their primary care or any other alternative care setting in a timely way.

Implications

The implications for this study include that it has identified a significant finding that improves upon other authors who have found negligible or no association between HFPC consult and HF readmissions. It also is the first study that provided individual follow-up of a retrospectively defined cohort (index HF hospitalization Oct 1 - Dec 31, 2019) and prospectively followed the cohort to observe their experience with HFPC consult, subsequent mortality events, and 90-day hospital readmission. This study has evaluated this question with substantial methodological rigor and would likely withstand the criticism of peer review. Limitations to the success of peer review would be that this study was conducted at a single site with availability and support for palliative care referrals. Not all hospital systems have similar levels of support or availability of palliative care practitioners, compromising generalizability. However, if such findings are reproducible in other settings with the availability and similar support for palliative care referral, it would be important that the dissemination of palliative care programs not be based on the flawed premise that installation of such a program will help in the objective to

decrease hospital 30-day readmissions as advocated by the HRRP. It further supports other researchers who have questioned the objectives of the HRRP that call for palliative care referral as a mechanism to decrease hospital 30-day readmissions. HFPC may support other important aspects of patient care but reducing hospital readmission is not an objective that can be achieved with HFPC consult.

It is important that hospital resources be utilized in the most useful and efficient ways. If HFPC resources are tasked with providing an HFPC consult to every patient with end-stage heart failure, with the primary intention that such referral will minimize hospital readmissions, it is a clear misuse of HFPC resources. HFPC may provide other necessary supports for decision-making and future health planning, which are important aspects of patient management. However, if the primary aim is to reduce hospital 30-day readmission, HFPC resources are being misspent.

The best outcome arising out of the implications of this study would be the refocusing and reallocation of HFPC resources to meet realizable goals and provide meaningful support for decision-making and future health planning. This may constitute the same population of HF patients with high morbidity, poor health knowledge, and limited social resources, but the objectives would be more closely aligned with quality-of-life issues rather than a hospital operations focus to reduce hospital readmissions, given the current state of the health care system that often focuses on operational efficiency imperatives that are measurable and have a direct contribution to the financial bottom line versus quality-of-life imperatives that are very difficult to measure and do not directly contribute to a financial bottom line.

Recommendations

Recommendations for future research include testing the reproducibility of this research at a similar site that supports referral of end-stage HF patients for an HFPC consult and has the availability of HFPC resources to provide consistent and timely access to those resources. It is known that there is broad variation in the level of PC services available at health systems across the country. A cross-sectional study to determine what services are provided in a PC consult should be conducted to standardize definitions for the level of service.

Likewise, it is important that the PC professional community define what the target population should be, what the objectives for treatment should be, and what the measurable outcomes should be. This standardization is necessary to ensure consistent dissemination of PC interventions that are identified in future research. As an observational study, this study could not establish causation. A randomized clinical trial would be more likely to provide further insight into the level of HFPC services that may exert a threshold effect and exert an influence on hospital readmissions. A cost-effectiveness study would be a value-add to health systems to explore whether it is more cost-effective to utilize HFPC resources to reduce hospital readmissions that continue to occur versus creating an alternative care setting that more directly meets the needs of the end-stage HF patient that may include HFPC but also provide access to the acute care interventions required by the patient in a timely and accessible way such that they do not need to seek acute care hospitalization.

Limitations and Delimitations

These findings may represent a hospital system that has developed a robust system for identifying and referring an HF patient to HFPC in a timely way. Such timely identification may reflect patients with more advanced disease or poorer medical and social coping mechanisms that

were not assessed in this study. While patients were matched on severity, health-seeking behaviors and coping mechanisms were beyond the scope of this study. Indeed, the referral patterns for this hospital may identify the individuals with the poorest health-seeking behaviors and the fewest social supports and coping mechanisms. Even though HFPC is appropriately offered as another aspect of treatment, it should not be viewed as a mechanism to reduce hospital 30-day readmissions.

The underlying natural variation within this investigation lies in the complexity of clinical care management, associated morbidity and mortality, prevalence and health care costs of heart failure, and the difficulty in developing reliable solutions that meet the complex and varied course of disease discussed in the previous sections of this dissertation. The optimal treatment regimen for HF continues to evolve with a significant body of literature and cannot be identified as a single best approach at this time, resulting in significant variations in care. Thus, significant treatment heterogeneity is unavoidable in any HF cohort.

Recent commentary has highlighted the importance of delineating the duration of HF, with a key aspect being the timing of initiation of HFPC with recommendations for early initiation to ensure a smooth and timely integration of HFPC services (von Schwarz et al., 2020). This issue is part of a larger issue, which is defining more specifically not only the timing of initiation of HFPC consultation but more specifically delineating the services that comprise the essential services that ensure HFPC effectiveness. While the scope of this question exceeds the scope of this investigation, it remains an important area for future research.

Insurance providers, including the US government by way of the Medicare program, have a vested interest in controlling costs associated with treatment, with the result that interventions to decrease hospital readmissions are likely to continue unless evidence is generated that such

administrative mandates demonstrate clear futility or harm. More importantly, patients and their families rely on health care providers and the broader health system to receive optimal, life-preserving medical care and quality of life. HFPC would appear to be the best option of addressing complex individualized care needs in an outpatient setting but requires validation. This research contributes to the development of incremental knowledge specific to the validity of HFPC interventions to decrease hospital readmissions after controlling for mortality. Also, this research addressed the underlying barriers and issues by addressing a specific gap in medical knowledge that has not been assessed (whether the effect of mortality on HFPC readmission rates is substantive or negligible and whether HFPC is an effective intervention for patients with end-stage heart disease to reduce 90-day hospital readmissions). Lastly, this investigation fully established that there is a statistically significant difference in 90-day hospital readmission between the cohort of subjects with an HFPC consult versus those with no HFPC consult with individuals with an HFPC consult realizing statistically significant earlier hospital readmission than their propensity-matched counterparts.

Summary

Recent administrative mandates from the Centers for Medicare and Medicaid Services (CMS) embodied in the Hospital Readmission Reduction Program (HRRP) have aimed to reduce the frequency of heart failure (HF) 30-day hospital readmissions. To fill the health care needs of patients with end-stage heart failure, palliative care (HFPC) and hospice referrals are promoted to provide additional support to patients in addition to their primary care and specialist physicians and reduce unnecessary hospital readmission. While HFPC is a plausible and logical intervention, effectiveness in achieving reductions in readmissions has not been assessed in a

heart failure population with adequate controls to assess potential sources of confounding and interaction.

Currently, hospital readmission metrics include in their numerator all patients with a diagnosis of HF who are readmitted within a 30-day time period with the denominator including all patients discharged with a diagnosis of HF. If the patient experiences a mortality event in the 30-day period after hospital discharge, there is no opportunity for readmission, and the mortality event does not accrue to the numerator of the admitting hospital readmission metric. Studies to date have evaluated the efficacy of palliative care to achieve reductions in hospital readmissions but have not evaluated this potential for significant differential mortality. This investigation assessed the mortality-adjusted, propensity-matched (severity-adjusted) relationship between HFPC consult and 90-day hospital readmission in patients with a diagnosis of end-stage heart failure (HF) in the current context of administrative mandates that aim to reduce the frequency of HF hospital readmissions.

Heart failure is the most common discharge diagnosis in the United States, affecting 5.1 million annually (Arora et al., 2017; Fasolino & Phillips, 2016). The Centers for Medicare and Medicaid Services (CMS) implemented components of the 2010 Affordable Care Act with the introduction of the Hospital Readmission Reduction Program (HRRP) and began to publicly report hospital 30-day all-cause risk-standardized mortality rates and 30-day all-cause risk-standardized readmission rates for acute myocardial infarction (AMI), heart failure (HF) and pneumonia (Krumholz et al., 2013). In October 2012, CMS introduced penalties and began reducing Medicare payments for excess readmissions in a broad array of inpatient hospitalizations, specifically HF, based on a ratio of predicted versus expected 30-day readmissions (Medicare, 2017). A higher-than-expected rate of thirty-day readmissions

following HF hospitalization can negatively impact hospital performance measures and incur reimbursement penalties (Davis et al., 2017).

The expansion of palliative care programs beyond cancer to end-stage organ failure patients is new and has received increasing popular attention worldwide in the last decade (Ng et al., 2016). A key element of the hospital interest in palliative care is the risk adjustment it affords the hospital submitting data for CMS readmission metrics. The presence of a coded palliative care consult (V667) or hospice referral on the electronic medical record of the patient admitted with HF increases the expected count of HF readmissions in CMS quality calculations and creates a greater opportunity for the hospital to have a less than the expected count of HF readmissions which translates into a higher quality score for the admitting hospital (Trivette, 2017).

Research evaluating the effectiveness of an HFPC consult in the setting of acute hospitalization for HF as an intervention to decrease 30-day hospital readmission has shown mixed results and methodological limitations. A broad array of guidelines promotes its adoption, while the literature has demonstrated poor reproducibility of the reliability of a PC consult to effectively reduce hospital readmissions (Chuang & Fausto, 2014; Chuang et al., 2017; Nelson et al., 2011; O'Connor et al., 2015; Wiskar et al., 2017). The goal of this research was to assess the effectiveness of HFPC consult to effect change in 90-day hospital readmissions in a propensity-matched model that adequately controls for mortality at a single-site 526-bed tertiary-care facility.

This research is relevant to several key health care areas, including heart failure, hospital readmissions, and palliative care. Heart failure prevalence is increasing, administrative pressures to reduce hospital readmissions show no sign of weakening, and alternative strategies like

palliative care require an evidence-based and methodologically rigorous evaluation of outcomes. The sustained incidence, increasing prevalence, and significant lifetime risk of HF create the strong imperative to improve all aspects of care associated with the diagnosis of HF. The prevalence of risk factors in the US population, the increasing prevalence of obesity and diabetes, the associated cost for care, and potentially significant increases in the future cost of care for patients with HF indicate a significant imperative to improve the care and management of individuals with HF. The challenges of a clinical syndrome with high mortality, complex medical management of multiple comorbidities, and challenges with identifying interventions with associated mortality benefit create the imperative for identifying new strategies, such as palliative care to prevent HF hospital readmission and improve management of patients with HF. The development of readmission metrics is flawed as a measure of hospital quality of care and is more likely to represent administrative priorities to promote the development of improved systems of care that incorporate individual and community aspects of care that are more likely to contribute to improved continuity of care and result in fewer unplanned hospital readmissions (Barnett et al., 2015; Chin et al., 2016; Freedland et al., 2016; National Quality Forum, 2016; Pandey et al., 2017). According to Cook et al. (2016), mortality risk increases after hospital readmission and never returns to pre-admission levels. Palliative care may provide the needed transition and continuity of care to address the observed increase in mortality risk associated with hospitalization.

The theoretical approach to this study employed the Common Sense Model in that the relationship between illness representations with inputs from the illness prototype, sensory inputs, and treatment beliefs, and the illness outcome of hospital readmission can be modified by improving coping procedures developed in the context of palliative care. CSM focuses on the

antecedent experience of severity (illness prototype) and concurrent inputs from the senses and treatment beliefs. Moreover, it considers the projected future consequences and potential for cure or control (illness representation) of the health-seeking behavior (Leventhal et al., 2016). The interpretation of symptoms and health-seeking behaviors for HF is complex, difficult to assess, and exerts a strong influence on the individual's illness representation and prompting health-seeking behaviors (Enguidanos et al., 2015; Kaptein et al., 2003; Leventhal et al., 2016; Turrise, 2016). Coping mechanisms have been demonstrated to improve illness outcomes (Leventhal et al., 2016; Turrise, 2016).

Statistical analysis encompassed:

a) logistic regression and odds ratio calculation of risk of the primary research question of interest, the dependent variable 90-day hospital readmission against the independent variables of mortality and severity (propensity-score) in both the propensity-matched and total unmatched population
b) demographic characterization of the total unmatched population and the resulting propensity-matched cohort
c) calculation of odds ratios for risk of HFPC consult based on demographic characteristics, markers of acuity, and comorbidity
d) sub-analysis of time to readmission with histograms and survival curve analysis

Results were statistically significant for a strong association between HFPC consult and 90-day hospital readmission in a propensity-matched population, *OR* 4.3, 95% CI [1.8-10.6]. Statistically significant differences in the demographic characteristics of the population were eliminated with propensity-matching but maintained strong model predictive ability with Cohen's d =0.83. Calculated ORs for obtaining HFPC consult provided insight into clinically

meaningful patient characteristics that predict HFPC consult. Time to readmission analysis demonstrated that patients with an HFPC consult have a different mean time to readmission, and survival analysis demonstrated the statistically significant differences in the experience of patients who received an HFPC consult compared to those that did not, $p < .0001$.

- <30% of HF patients who have an HFPC consult are unable to avoid hospital readmission for >90 days.
- >50% of HF patients who have an HFPC consult experience a hospital readmission within 30 days of discharge.
- 75% of HF patients who have an HFPC consult will have a hospital readmission within 90 days of discharge.

This study demonstrated that while HFPC may be an important aspect of continuity of care and care planning for the HF patient, it is not a valid or effective method for reducing 90-day hospital readmissions. In this investigation, HFPC consult was predicted by and served as a proxy for the HF patient that has an acute decompensation with abnormal lab values on admission, with numerous comorbidities or approaching end-of-life. HFPC consultation has many values in the care and management of the HF patient. However, reducing 90-day hospital readmission is not an achievable goal. Conversely, HFPC consult should serve as a proxy signal to expect the increased frequency of admissions in a population with high morbidity approaching end-of-life.

It is important that hospital resources be utilized in the most useful and efficient ways. If HFPC resources are tasked with providing an HFPC consult to every patient with end-stage heart failure, with the primary intention that such referral will minimize hospital readmissions, it is a clear misuse of limited PC resources. HFPC may certainly provide other necessary supports for

decision-making and future health planning, which are important aspects of patient management. However, if the primary aim is to reduce hospital 30-day readmission, PC resources are being misspent.

The best outcome arising out of the implications of this study would be the refocusing and reallocation of PC resources to meet realizable goals and provide meaningful support for decision-making and future health planning. This may constitute the same population of HF patients with high morbidity, poor health knowledge, and limited social resources, but the objectives would be more closely aligned with quality of life issues rather than a hospital operations focus to reduce hospital readmissions, given the current state of the health care system that too often focuses on operational efficiency imperatives that are measurable and have a direct contribution to the financial bottom line versus quality of life imperatives that are more difficult to measure.

Appendices

Appendix A1

Table A1

Summary of Findings Pertaining to HF Readmission Rates

Author	Time span	n	All-cause 30-day HF readmission rate	Comment
(Krumholz et al., 2009)	Jul 2005 - Jun 2008	1,430,053	Median 24.4% (range 15.9% to 34.4%; 25th to 75th percentile 23.4% to 25.6%)	
(DeVore et al., 2016)	2006 - 2012	100,189	2006 - 7 21.5% 2007 - 8 21.8% 2008 - 9 22.2% 2009 - 10 22.2% 2010 - 11 22.1% 2011 - 12 22.5%	Adjusted trend Before public reporting 0.0% (-1.4 to 1.5) After public reporting -1.8% (-3.3 to -0.2)
(Bergethon et al., 2016)	2009 - 2012	21,264	2009 20.0% (SD, 1.3%) 2012 19.0% (SD, 1.2%) (p =0.001) Trend in relative HRR by quartile of performance Q1(best), Q4(worse) Q1 -0.9% (13.1 to 4.8) Q2 -4.9% (-7.4 to 0.5) Q3 -7.0% (-10.4 to -2.6) Q4 -8.7% (-12.9 to -5.0)	Get With the Guidelines is a voluntary program
(Wasfy et al., 2017)	Jan 2000 - Nov 30, 2013	2868 hospitals	Risk-standardized rates per 10,000 discharges per year Pre-ACA law 5.1 (4.8 to 5.3) Post-ACA law -84.7 (-83.9 to -85.4)	Averted admissions by quartile of performance Q1(best) Q4(worse) Q1 77.6 (76.4 to 79.2) Q2 86.8 (85.6 to 88.0) Q3 100.8 (98.4 to 102.8) Q4 112.0 (108.0 to 115.6)
(Zuckerman et al., 2016)	Oct 2007 - May 2015	3387 hospitals	2007 - 08 21.5% 2014 - 15 17.8% Slope of change: Oct 2007 - Apr 2010 -0.017 Apr 2010 - Oct 2012 -0.103 Oct 2012 - Apr 2015 -0.005	Aggregate HRR for all target conditions inclusive of AMI, HF, and pneumonia
(Desai et al., 2016)	Jan 2008 - Jun 2015	48,137,102 hospitalizations 20,351,161 Medicare enrollees	Penalty hospitals 2008 27.5% mean HRR Difference in annualized rate of change: 2008 - 2010 0.10% (-0.12 to 0.32) 2010 - 2012 -0.50% (-1.18 to -0.62) 2012 - 2015 0.72% (0.40 to 0.95)	2010 - 2012 Penalty hospitals had a -1.25% difference in annualized rate of change as compared to non-penalty hospitals.

			No penalty hospitals: 2008 24.2% mean HRR 2008 - 2010 -0.26% (-0.56 to 0.04) 2010 - 2012 0.08% (-0.30 to 0.46) 2015 - 2015 0.14% (-0.17 to 0.46)	
(Sukul et al., 2017)	2014	98,315 index HF admits 21,054 HF readmissions	Younger patients 18 - 64 had higher rates of readmission (21.4%) compared to elderly patients (20.7%) $p < 0.001$	
(Gilotra et al., 2017)	Jul 2014 - Mar 2015	93	29 (30%)	HF 30-day readmission rate 17 (18%)

Appendix A2

Table A2

Summary of Findings Pertaining to HF Readmission Rates and Mortality

Author	Dates	n	30-day mortality before public reporting	30-day mortality after public reporting	Comment
(Krumholz et al., 2009)	Jul 2005 - Jun 2008	1,161,165	Median 11.1% (range, 6.6 to 19.8%)		
(Krumholz et al., 2013)	Jul 2005 - Jun 2008	4767 hospitals 1,161,179 patients	Correlation between mortality rates and readmission rates was *r2* =-0.17, 95% CI [-0.20 to -0.14]		
(Arundel et al., 2016)	1998 - 2001	7578	12-month mortality for patients with 30-day readmit 41% With no 30-day readmission, 27%		*HR* 1.68, $p <$ 0.001, 95% CI [1.48 - 1.90]
(Cook et al., 2016)	2003 - 2006	3993			37% net increase in mortality risk subsequent to 30-day hospital readmission.
(DeVore et al., 2016)	2006 - 2012	100,189	Adjusted all-cause mortality trend -2.4% (-6.2 to 1.6)	Adjusted all-cause mortality trend 3.1% (-1.3 to 7.6)	p =0.15
(Bergethon et al., 2016)	2009 - 2012	21,264	2009 7.8%	2012 7.6%	p =0.71
(Dharmarajan et al., 2017)	2008 - 2014	2,962,554 hospitalizations 4772 hospitals	2008 8.4% 30-day post discharge mortality	2014 9.2%	Trend increased 0.008% (0.007% to 0.010%) monthly
(Fonarow et al., 2017)	2008 - 2014	Reanalysis of Dharmarajan 2017	2008 Observed 7.9%	2014 Observed 9.2%	Delta 2.6% mortality increase

			Expected 7.9%	Expected 6.6%	
(Gupta et al., 2017)	Jan 1, 2006 - Dec 31, 2014	115,245 pts 416 hospitals	7.2% 30-day post-discharge mortality	9.2% 30-day *HR* 1.15, 95% CI [1.08 - 1.24] 1-yr *HR* 1.10, 95% CI [1.07 - 1.14]	Population subset from AHA Get With the Guidelines voluntary registry
(Chatterjee & Joynt Maddox, 2018)	2009 - 2015	2009 - 2751 2015 - 3796 hospitals	30-day HF mortality decreased -0.12% per year among baseline poor performers	30-day HF mortality increased 0.17% per year among all other hospitals	$p < .001$
(Wadhera, Joynt Maddox, Wang, Shen, & Yeh, 2018)	Jul 1,2011 - Jun 30, 2014	1,343,792 pts, 2948 hospitals	High versus Low 30-day episode payments associated with Mortality *OR* 0.969, $p < 0.001$		Cautionary for programs that incentivize reduced payments like HRRP
(Khera, Dharmarajan, & Krumholz, 2018)	Jan 1, 2006 - Dec 31, 2014	4,000,000 HF hospitalizations	Trend increasing 0.004% per month pre-HRRP	Trend for in-hospital mortality decreased from 4.3% to 3.5%, post-discharge mortality increased from 7.4% to 9.2%.	Combines divergent in-hospital and post-discharge trends to report overall nonsignificant mortality trend.

Appendix A3

Table A3

Summary of Findings Pertaining to HF Readmission Rates and Palliative Care

Study	Dates	n	Intervention	Outcomes	Risk of bias assessment (Higgins et al., 2011; Savovic et al., 2018)
(Rabow et al., 2004)	Not reported	n=90 40 usual primary care 50 PC intervention	Interdisciplinary PC team meetings led by PC MD providing: (a) written recommendations to PCP in five domains of PC at study entry, midway, and end. (b) Social work case management (c) RN led family caregiver training (d) Pharmacist medication review (e) Chaplain offered spiritual and psychological support (f) Monthly patient and family support groups (g) Weekly telephone contact, monthly visits providing communication with PC team about patient needs.	Physical UCSD SOB p =0.01 Brief Pain Inventory (ns) Sleep items from MOS p =0.05 Psychological Profile of Mood States (ns) CES Depression scale (ns) Spiritual Spiritual well-being scale p =0.007 Social QoL scale-Cancer (ns) Health care satisfaction GHAA survey (ns) Advanced care planning p =0.03 in one of three outcomes Utilization Clinic visits p =0.03 Urgent care p =0.04 Specialist, ED visits, hospital admissions, hospital days, and charges (ns) Mortality (ns)	Moderate risk of bias. Site randomized, no subject randomization. Unblinded Mixed subject population with HF minority (34 - 35%). Selection bias with 58% (intervention) to 65% (control) refused to enroll because they were "too ill." N.B. Pain and depression recommendations were rarely implemented.
(Aiken et al., 2006)	Jul 1999 - Mar 2001	N=192 91 usual care 101 PC intervention	PhoenixCare intervention with service delivery by RN case managers conducting home visits, phone calls, and accompanying patients to MD visits	Receipt of sufficient information or education $p < 0.05$ for four of 12 outcomes Preparation for end-of-life $p < 0.05$ for two of 10 outcomes. Symptom burden $p <$ 0.05 for one of six outcomes.	High risk of bias. Mixed subject population affecting generalizability to HF patients. Subjective outcomes using non-validated instruments Unblinded

				SF-36 physical and mental functioning $p <$ 0.05 for two out of eight domains for HF subset. ED visits (ns)	High loss to follow-up, retaining 43% of intervention pts. and 33% of control pts.
(Brumley et al., 2007)	Sep 2002 - Mar 2004	n=298 155 usual care 155 PC intervention	Terminally ill participants randomized to usual care or in-home palliative care with an assigned coordinating PC physician preventing service fragmentation.	Satisfaction with care $p <$ .05, decreased use of medical services (ED visits) p =.01, site of death at home $p <$ .001, lower costs of care p =.03	High risk of bias. Unblinded Population not representative of HF population (33% HF). Intervention representative of hospice not palliative care.
(Pantilat, O'Riordan, Dibble, & Landefeld, 2010)	Jan 2002 - Dec 2003	n=107 53 usual care 54 PC intervention	Daily inpatient PC visits and phone call two weeks after discharge.	Symptom rating 0 - 10 of pain (ns), dyspnea (ns), and anxiety (ns).	High risk of bias. Single center, unblinded (blinded assessments)
(Brannstrom & Boman, 2014)	Jan 2011 - Oct 2012 Sweden	n=72 36 usual care 36 PC intervention	PREFER - Multidisciplinary in-home disease management and PC services Nurse visits p =0.0001 MD phone calls or Rx meds (ns) MD visits (ns)	Symptom burden (ESAS) (ns) Quality-of-life EuroQol (EQ-5D) p =0.05 (KCCQ) (ns) Survival at six months. (ns) Total Readmissions p =0.009	High risk of bias. Single center, unblinded Core health system differences limit generalizability to the US. Differential allocation to control or intervention by age
(Sidebottom et al., 2015)	Apr 2012 - Feb 2013 US	n=232 116 usual care 116 PC intervention	Standard process of hospital PC team and survey responses to MLHFQ, ESAS, and PHQ-9 acquired at baseline interview and no patient cost for initial PC consult.	Quality-of-life (MLHFQ) $p <$ 0.0001 at one or three months. Symptom management (ESAS) $p <$ 0.0001 at one or three months. Depression (PHQ-9) $p <$ 0.0001 at one or three months. Advance care planning p =0.033 at six months 30-day readmission (ns) Hospice use (ns) at six months Mortality (ns) at six months	High risk of bias Single center, unblinded Selection bias - enrolled subjects not ordered for standard of care PC referral Financial compensation to intervention subjects providing free initial PC consult. Differential loss to follow-up with 80% of individuals in the intervention arm receiving only one initial visit.

(Bekelman et al., 2015)	May 2009 - Jun 2011 US	n=392 197 usual care 187 intervention	Multidisciplinary collaborative care HF disease management: Screening for and treatment of depression Telemonitoring with patient self-care support	Quality-of-life (KCCQ) (ns) Mortality p =0.04 1-year hospital Readmission (ns) Subgroup analysis of HF patients with Depression (PHQ-9) p =0.01	Equivocal risk of bias Very high variance in KCCQ trajectories (range 0 - 100) Unblinded patient intervention (blinded outcome assessments)
(Hopp et al., 2016)	Sep 2006 - Jun 2008 US	n=85 43 usual care 42 PC intervention	At least one inpatient PC consultation, with the opportunity for additional meetings.	Election versus non-election of comfort-oriented care (hospice or "do not resuscitate" order) (ns) Quasi-qualitative reasons for non-participation abstracted from medical record.	High risk of bias Unblinded 92% African American patient population and predominantly White caregivers providing service.
(Wong et al., 2016)	May 2013 - Dec 2014 Hong Kong	n=84 41 usual care 43 PC intervention	MD supported RN case managers provided patient visits, training, home visits and telephone visits weekly for the first four weeks, then monthly through 12 weeks.	Readmission at four weeks (ns) and 12 weeks (p =0.009) Symptom intensity (ESAS)(ns) Functional status (PPS) (ns) Quality-of-life MQOL-HK p < 0.001 at 12 weeks, CHHQ p < 0.001 at 12 weeks) Satisfaction with care (ns)	High risk of bias Differential loss-to-follow-up (25% control, 14% intervention (I) Differential allocation to control or intervention by HF class (I) Differential allocation to control or intervention for advanced HF interventions (CRT and Pacemaker) (I) Core health system differences limiting generalizability.
(Rogers et al., 2017)	Aug 2012 - Jun 2015 US	n=150 75 usual care 75 PC intervention	Interdisciplinary, guideline-driven, multicomponent PC intervention with contemporary HF management. PC MD led team with PC NP collaborating with cardiology and a focus on shared goal setting. After discharge NP participated in ongoing patient management.	Quality-of-life KCCQ, FACIT-PAL p =0.021 Anxiety and depression HADS p =0.063 Spiritual well-being FACIT-Sp p =0.031 Hospitalizations (ns) Mortality (ns)	Low-Moderate risk of bias Unblinded intervention Single center 12% loss to follow-up Selection bias - subjects recruited from established HF program

(Bekelman et al., 2018)	Aug 2012 - Apr 2015	N=314 157 usual care 157 PC intervention	Psychosocial care model - Collaborative Care to Alleviate Symptoms and Adjust to Illness (CASA) RN symptom evaluation Social worker providing psychosocial care Consulting team, including PC, PCP, and Cardiology providing orders for tests and medications to patients' PCP for review and signature.	Quality-of-life (KCCQ) (ns) Depression (PHQ-9) p =0.02 Anxiety (GADQ) (ns) Global symptoms (GSD)(ns) Specific symptoms: pain (ns), fatigue p =0.02, shortness of breath (ns) Hospitalizations (ns) Mortality at three and six months(ns)	Low risk of bias Multi-site Single blind SOC PC consultation delivered to usual care arm.

Appendix A4

Table A4

2020 ICD-10-CM Heart Failure Diagnostic Codes

Code	Description
I09.81	Rheumatic heart failure
I11.0	Hypertensive heart disease with heart failure
I50	Heart failure
I50.1	Left ventricular failure, unspecified
I50.2	Systolic (congestive) heart failure
I50.20	Unspecified systolic (congestive) heart failure
I50.21	Acute systolic (congestive) heart failure
I50.22	Chronic systolic (congestive) heart failure
I50.23	Acute on chronic systolic (congestive) heart failure
I50.3	Diastolic (congestive) heart failure
I50.30	Unspecified diastolic (congestive) heart failure
I50.31	Acute diastolic (congestive) heart failure
I50.32	Chronic diastolic (congestive) heart failure
I50.33	Acute on chronic diastolic (congestive) heart failure
I50.4	Combined systolic (congestive) and diastolic (congestive) heart failure
I50.40	Unspecified combined systolic (congestive) and diastolic (congestive) heart failure
I50.41	Acute combined systolic (congestive) and diastolic (congestive) heart failure
I50.42	Chronic combined systolic (congestive) and diastolic (congestive) heart failure
I50.43	Acute on chronic combined systolic (congestive) and diastolic (congestive) heart failure
I50.8	Other heart failure
I50.81	Right heart failure
I50.810	Right heart failure, unspecified
I50.811	Acute right heart failure
I50.812	Chronic right heart failure
I50.813	Acute on chronic right heart failure
I50.814	Right heart failure due to left heart failure
I50.82	Biventricular heart failure
I50.83	High output heart failure
I50.84	End stage heart failure
I50.89	Other heart failure
I50.9	Heart failure, unspecified

Excluding:

000 - 007, 008.8	Heart failure complicating abortion or ectopic or molar pregnancy
008.8	Other complications following an ectopic and molar pregnancy
075.4	Heart failure complicating obstetrical procedure or delivery
I13.0	Hypertensive heart and chronic kidney disease with heart failure and stage one through four chronic kidney disease, or unspecified chronic kidney disease
I13.2	Hypertensive heart and chronic kidney disease with heart failure and with stage five chronic kidney disease, or end stage renal disease
I46	Cardiac arrest
I97.13	Postprocedural heart failure
P29.0	Heart failure originating in the perinatal period
R57.0	Cardiogenic shock
R57.9	Shock, unspecified

Including MS-DRG v37.0:

222	Cardiac defibrillator implant with cardiac catheterization with ami or hf or shock with mcc
223	Cardiac defibrillator implant with cardiac catheterization with ami or hf or shock without mcc
291	Heart failure and shock with mcc
292	Heart failure and shock with cc
293	Heart failure and shock without cc or mcc

Excluding MS-DRG v37.0:

791	Prematurity with major problems
793	Full term neonate with major problems

Appendix A5

Table A5

ICD-10-CM Comorbidities Pertaining to HF Propensity-Matching (Quan et al., 2005)

TABLE 2. ICD-9-CM and ICD-10 Coding Algorithms for Elixhauser Comorbidities

Comorbidities	Elixhauser's Original ICD-9-CM	Elixhauser AHRQ-Web ICD-9-CM	ICD-10	Enhanced ICD-9-CM
Congestive heart failure	398.91, 402.11, 402.91, 404.11, 404.13, 404.91, 404.93, 428.x	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.x	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5–I42.9, I43.x, I50.x, P29.0	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428.x
Cardiac arrhythmias	426.10, 426.11, 426.13, 426.2–426.53, 426.6–426.8, 427.0, 427.2, 427.31, 427.60, 427.9, 785.0, V45.0, V53.3	—	I44.1–I44.3, I45.6, I45.9, I47.x–I49.x, R00.0, R00.1, R00.8, T82.1, Z45.0, Z95.0	426.0, 426.13, 426.7, 426.9, 426.10, 426.12, 427.0–427.4, 427.6–427.9, 785.0, 996.01, 996.04, V45.0, V53.3
Valvular disease	093.2, 394.0–397.1, 424.0–424.91, 746.3–746.6, V42.2, V43.3	093.2, 394.x–397.1, 397.9, 424.x, 746.3–746.6, V42.2, V43.3	A52.0, I05.x–I08.x, I09.1, I09.8, I34.x–I39.x, Q23.0–Q23.3, Z95.2–Z95.4	093.2, 394.x–397.x, 424.x, 746.3–746.6, V42.2, V43.3
Pulmonary circulation disorders	416.x, 417.9	416.x, 417.9	I26.x, I27.x, I28.0, I28.8, I28.9	415.0, 415.1, 416.x, 417.0, 417.8, 417.9
Peripheral vascular disorders	440.x, 441.2, 441.4, 441.7, 441.9, 443.1–443.9, 447.1, 557.1, 557.9, V43.4	440. x, 441.x, 442.x, 443.1–443.9, 447.1, 557.1, 557.9, V43.4	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9	093.0, 437.3, 440.x, 441.x, 443.1– 443.9, 447.1, 557.1, 557.9, V43.4
Hypertension, uncomplicated	401.1, 401.9	401.1, 401.9, 642.0	I10.x	401.x
Hypertension, complicated	402.10, 402.90, 404.10, 404.90, 405.1, 405.9	401.0, 402.x–405.x, 642.1, 642.2, 642.7, 642.9	I11.x–I13.x, I15.x	402.x–405.x
Paralysis	342.0, 342.1, 342.9–344.x	342.x–344.x, 438.2–438.5	G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0–G83.4, G83.9	334.1, 342.x, 343.x, 344.0–344.6, 344.9
Other neurological disorders	331.9, 332.0, 333.4, 333.5, 334.x, 335.x, 340.x, 341.1–341.9, 345.0, 345.1, 345.4, 345.5, 345.8, 345.9, 348.1, 348.3, 780.3, 784.3	330.x–331.x, 332.0, 333.4, 333.5, 334.x–335.x, 340, 341.1–341.9, 345.x, 347.x, 780.3, 784.3	G10.x–G13.x, G20.x–G22.x, G25.4, G25.5, G31.2, G31.8, G31.9, G32.x, G35.x–G37.x, G40.x, G41.x, G93.1, G93.4, R47.0, R56.x	331.9, 332.0, 332.1, 333.4, 333.5, 333.92, 334.x–335.x, 336.2, 340.x, 341.x, 345.x, 348.1, 348.3, 780.3, 784.3
Chronic pulmonary disease	490–492.8, 493.00–493.91, 494.x–505.x, 506.4	490x–492.x, 493.x, 494x–505.x, 506.4	I27.8, I27.9, J40.x–J47.x, J60.x–J67.x, J68.4, J70.1, J70.3	416.8, 416.9, 490.x –505.x, 506.4, 508.1, 508.8
Diabetes, uncomplicated	250.0–250.3	250.0–250.3, 648.0	E10.0, E10.1, E10.9, E11.0, E11.1, E11.9, E12.0, E12.1, E12.9, E13.0, E13.1, E13.9, E14.0, E14.1, E14.9	250.0–250.3
Diabetes, complicated	250.4–250.7, 250.9	250.4–250.9, 775.1	E10.2–E10.8, E11.2–E11.8, E12.2–E12.8, E13.2–E13.8, E14.2–E14.8	250.4–250.9
Hypothyroidism	243–244.2, 244.8, 244.9	243–244.2, 244.8, 244.9	E00.x–E03.x, E89.0	240.9, 243.x, 244.x, 246.1, 246.8
Renal failure	403.11, 403.91, 404.12, 404.92, 585.x, 586.x, V42.0, V45.1, V56.0, V56.8	403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 585.x, 586.x, V42.0, V45.1, V56.x	I12.0, I13.1, N18.x, N19.x, N25.0, Z49.0–Z49.2, Z94.0, Z99.2	403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 585.x, 586.x, 588.0, V42.0, V45.1, V56.x
Liver disease	070.32, 070.33, 070.54, 456.0, 456.1, 456.2, 571.0, 571.2–571.9, 572.3, 572.8, V42.7	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 456.0, 456.1, 456.20, 571.0, 571.2–571.9, 572.3, 572.8, V42.7	B18.x, I85.x, I86.4, I98.2, K70.x, K71.1, K71.3–K71.5, K71.7, K72.x–K74.x, K76.0, K76.2–K76.9, Z94.4	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 070.6, 070.9, 456.0–456.2, 570.x, 571.x, 572.2–572.8, 573.3, 573.4, 573.8, 573.9, V42.7

(*Continued*)

TABLE 2. (*Continued*)

Comorbidities	Elixhauser's original ICD-9-CM	Elixhauser AHRQ-Web ICD-9-CM	ICD-10	Enhanced IC-9-CM
Peptic ulcer disease excluding bleeding	531.70, 531.90, 532.70, 532.90, 533.70, 533.90, 534.70, 534.90, V12.71	531.41, 531.51, 531.61, 531.7, 531.91, 532.41, 532.51, 532.61, 532.7, 532.91, 533.41, 533.51, 533.61, 533.7, 533.91, 534.41, 534.51, 534.61, 534.7, 534.91	K25.7, K25.9, K26.7, K26.9, K27.7, K27.9, K28.7, K28.9	531.7, 531.9, 532.7, 532.9, 533.7, 533.9, 534.7, 534.9
AIDS/HIV	042.x–044.x	042.x–044.x	B20.x–B22.x, B24.x	042.x–044.x
Lymphoma	200.x–202.3x, 202.5–203.0, 203.8, 238.6, 273.3, V10.71, V10.72, V10.79	200.x–202.3, 202.5–203.0, 203.8, 238.6, 273.3	C81.x–C85.x, C88.x, C96.x, C90.0, C90.2	200.x–202.x, 203.0, 238.6
Metastatic cancer	196.x–199.x	196.x–199.x	C77.x–C80.x	196.x–199.x
Solid tumor without metastasis	140.x–172.x, 174.x, 175.x, 179.x–195.x, V10.x	140.x–172.x, 174.x, 175.x, 179.x–195.x	C00.x–C26.x, C30.x–C34.x, C37.x–C41.x, C43.x, C45.x–C58.x, C60.x–C76.x, C97.x	140.x–172.x, 174.x–195.x
Rheumatoid arthritis/ collagen vascular diseases	701.0, 710.x, 714.x, 720.x, 725.x	701.0, 710.x, 714.x, 720.x, 725.x	L94.0, L94.1, L94.3, M05.x, M06.x, M08.x, M12.0, M12.3, M30.x, M31.0–M31.3, M32.x–M35.x, M45.x, M46.1, M46.8, M46.9	446.x, 701.0, 710.0–710.4, 710.8, 710.9, 711.2, 714.x, 719.3, 720.x, 725.x, 728.5, 728.89, 729.30
Coagulopathy	286.x, 287.1, 287.3–287.5	286.x, 287.1, 287.3–287.5	D65–D68.x, D69.1, D69.3–D69.6	286.x, 287.1, 287.3–287.5
Obesity	278.0	278.0	E66.x	278.0
Weight loss	260.x–263.x	260.x–263.x, 783.2	E40.x–E46.x, R63.4, R64	260.x–263.x, 783.2, 799.4
Fluid and electrolyte disorders	276.x	276.x	E22.2, E86.x, E87.x	253.6, 276.x
Blood loss anemia	280.0	280.0, 648.2	D50.0	280.0
Deficiency anemia	280.1–281.9, 285.9	280.1–281.9, 285.2, 285.9	D50.8, D50.9, D51.x–D53.x	280.1–280.9, 281.x
Alcohol abuse	291.1, 291.2, 291.5–291.9, 303.9, 305.0, V113	291.0–291.3, 291.5, 291.8, 291.9, 303.x, 305.0	F10, E52, G62.1, I42.6, K29.2, K70.0, K70.3, K70.9, T51.x, Z50.2, Z71.4, Z72.1	265.2, 291.1–291.3, 291.5–291.9, 303.0, 303.9, 305.0, 357.5, 425.5, 535.3, 571.0–571.3, 980.x, V11.3
Drug abuse	292.0, 292.82–292.89, 292.9, 304.0, 305.2–305.9	292.0, 292.82–292.89, 292.9, 304.x, 305.2–305.9, 648.3	F11.x–F16.x, F18.x, F19.x, Z71.5, Z72.2	292.x, 304.x, 305.2–305.9, V65.42
Psychoses	295.x–298.x, 299.1	295.x–298.x, 299.1	F20.x, F22.x–F25.x, F28.x, F29.x, F30.2, F31.2, F31.5	293.8, 295.x, 296.04, 296.14, 296.44, 296.54, 297.x, 298.x
Depression	300.4, 301.12, 309.0, 309.1, 311	300.4, 301.12, 309.0, 309.1, 311	F20.4, F31.3–F31.5, F32.x, F33.x, F34.1, F41.2, F43.2	296.2, 296.3, 296.5, 300.4, 309.x, 311

Appendix A6

Figure A6

Palliative Care Automatic Consult Criteria

Palliative Care Automatic Consult Criteria

Patient must meet both criteria to be eligible for the automatic palliative care consult

❑ - Patient has a diagnosis of CHF/COPD/PNA or STROKE

and

❑ - Patient must have <u>at least</u> one of the following conditions/criteria:

Nursing or Case Management Assessment

- ❑ Dialysis dependent renal failure
- ❑ Oxygen dependent COPD with SOB at rest
- ❑ Progressive or metastatic malignancy
- ❑ Severe neurological injury including CVA and trauma
- ❑ Advanced CHF/CAD/cardiomyopathy EF < 25% (If Available)
- ❑ 2nd hospitalization for similar disease process in last 60 days
- ❑ Liver failure with encephalopathy or a major bleeding episode requiring blood transfusion
- ❑ History of frequent falls
- ❑ >1 ED visits within last 30 days
- ❑ Other life limiting or serious progressive illness
  (For Example: AIDS but not just HIV infection, MS, Advanced Dementia, etc.)

Case Management Assessment

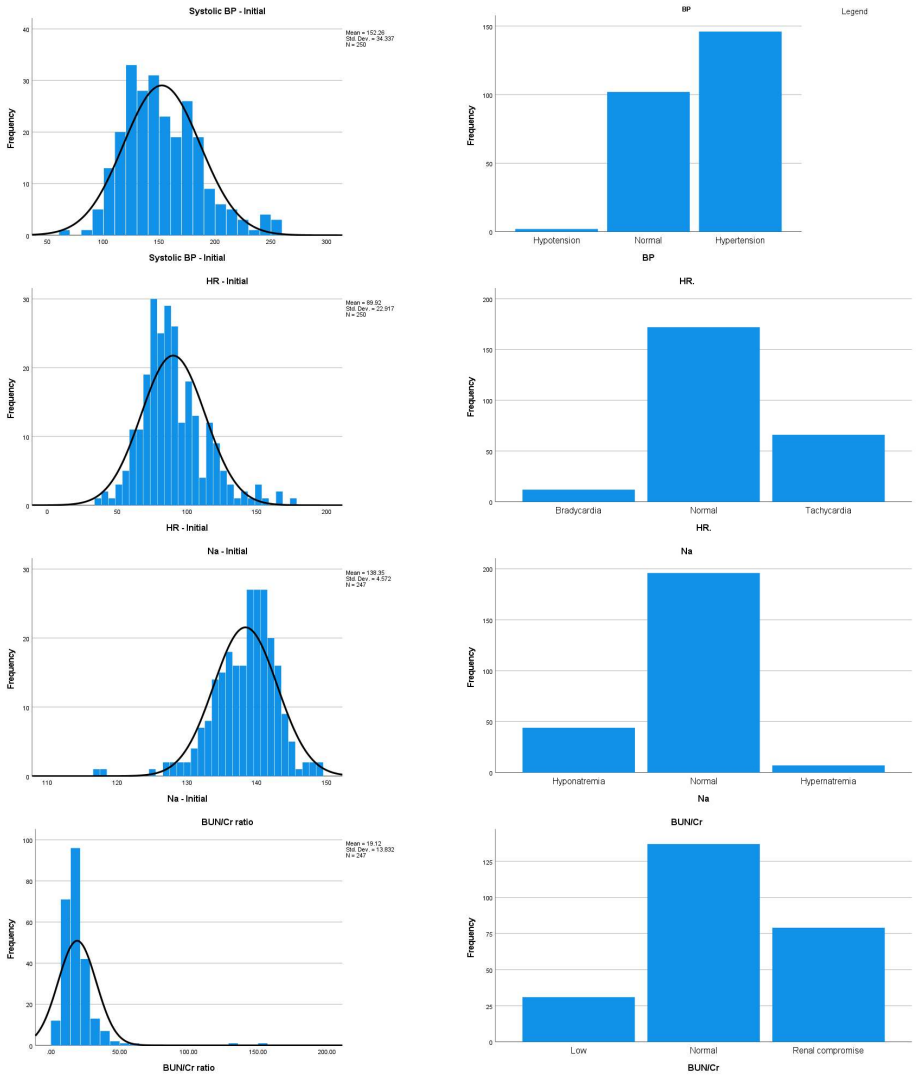
- ❑ Previous palliative care consult ordered
- ❑ 3 or more readmissions for similar disease process within last 6 months
- ❑ Prior refusal of post-acute services

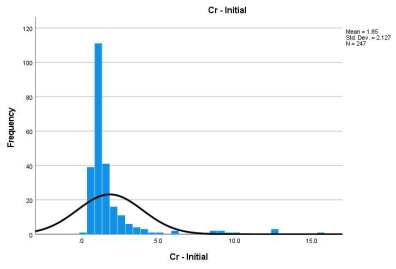
❑ - If above criteria are met, nurse or case management enters an order to Consult Physician: Dr. Mary Alfano-Torres

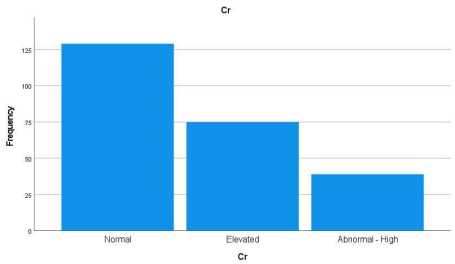
Appendix A7

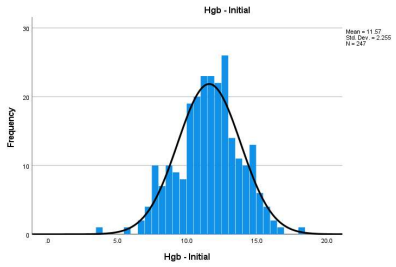
Figure A7

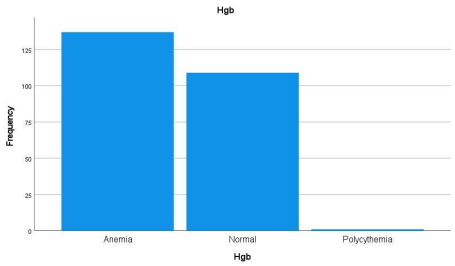
Variable Histograms Demonstrating Normal Distribution of Values and Transformed Strata

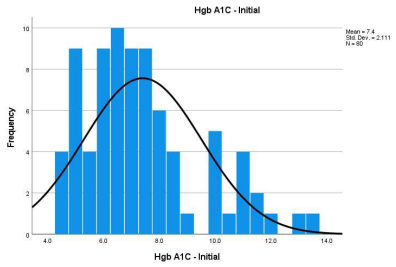


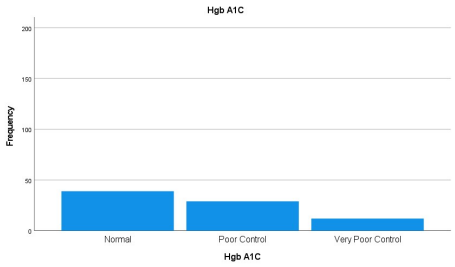

Cr - Initial
Mean = 1.85
Std. Dev. = 2.127
N = 247
Frequency
Cr - Initial


Cr
Frequency
Normal
Elevated
Abnormal - High
Cr


Hgb - Initial
Mean = 11.57
Std. Dev. = 2.255
N = 247
Frequency
Hgb - Initial


Hgb
Frequency
Anemia
Normal
Polycythemia
Hgb


Hgb A1C - Initial
Mean = 7.4
Std. Dev. = 2.111
N = 80
Frequency
Hgb A1C - Initial


Hgb A1C
Frequency
Normal
Poor Control
Very Poor Control
Hgb A1C

Appendix A8

Table A6

Dependent Variable Encoding

Original Value	Internal Value
No	0
Yes	1

Categorical Variables Codings

			Parameter coding					
		Frequency	(1)	(2)	(3)	(4)	(5)	(6)
Discharge disposition	Home - 0	126	.000	.000	.000	.000	.000	.000
	Home W/	48	1.000	.000	.000	.000	.000	.000
	Hospice	10	.000	1.000	.000	.000	.000	.000
	Inpt Reh	3	.000	.000	1.000	.000	.000	.000
	Long Ter	4	.000	.000	.000	1.000	.000	.000
	Short Te	2	.000	.000	.000	.000	1.000	.000
	Skilled	41	.000	.000	.000	.000	.000	1.000
Tobacco Use	Denies	132	.000	.000	.000	.000		
	Tob<30d	32	1.000	.000	.000	.000		
	Tobuse1+	57	.000	1.000	.000	.000		
	Tobuse30	8	.000	.000	1.000	.000		
	Unable t	5	.000	.000	.000	1.000		
Hospitalization duration	Admissio	87	.000	.000				
	Observat	72	1.000	.000				
	Prolonge	75	.000	1.000				
Primary Insurance	Commerci	148	.000	.000				
	Medicaid	6	1.000	.000				
	Medicare	80	.000	1.000				
	.25 Redu	59	1.000	.000				

Ejection	.25-.50	84	.000	1.000
Fraction cohort	.50+ Pre	91	.000	.000
Age cohort	< 55	49	.000	.000
	55-75	99	1.000	.000
	75+	86	.000	1.000
BP	Hyperten	139	1.000	.000
	Hypotens	2	.000	1.000
	Normal	93	.000	.000
HR.	0 Normal	163	.000	.000
	1 Bradyc	11	1.000	.000
	2 Tachyc	60	.000	1.000
Na	Hypernat	7	1.000	.000
	Hyponatr	40	.000	1.000
	Normal	187	.000	.000
Cr	Abnormal	36	1.000	.000
	Elevated	72	.000	1.000
	Normal	126	.000	.000
BUN/Cr	Low	25	.000	.000
	Normal	131	1.000	.000
	Renal co	78	.000	1.000
Guideline	No	114	1.000	
Adherance	Yes	120	.000	
Gender	Female	120	1.000	
	Male	114	.000	
Do Not	.	219	.000	
Resuscitate	DNR	15	1.000	
Hgb	Anemia	129	1.000	
	Normal	105	.000	
Intra Aortic	No	233	.000	
Balloon Pump	Yes	1	1.000	
AICD or CRT-	No	172	.000	
D Implant	Yes	62	1.000	
	No	225	.000	

Pressors required	Yes	9	1.000			

Appendix A9

Table A7

Classification Table[a]

			Predicted		
			Palliative Care Consult		Percentage
	Observed		No	Yes	Correct
Step 1	Palliative Care Consult	No	126	16	88.7
		Yes	20	72	78.3
	Overall Percentage				84.6

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Age cohort			4.132	2	.127	
	Age cohort(1)	-1.716	.876	3.839	1	.050	.180
	Age cohort(2)	-.911	.928	.963	1	.326	.402
	Gender(1)	1.079	.634	2.899	1	.089	2.943
	Do Not Resuscitate(1)	.945	1.939	.238	1	.626	2.574
	Primary Insurance			3.799	2	.150	
	Primary Insurance(1)	-23.386	13055.527	.000	1	.999	.000
	Primary Insurance(2)	1.300	.667	3.799	1	.051	3.670
	Ejection Fraction cohort			2.558	2	.278	
	Ejection Fraction cohort(1)	1.110	.803	1.910	1	.167	3.035

Ejection Fraction cohort(2)	-.005	.656	.000	1	.994	.995
AICD or CRT-D Implant(1)	1.140	.670	2.898	1	.089	3.127
Guideline Adherance(1)	.906	.582	2.420	1	.120	2.475
Hospitalization duration			.581	2	.748	
Hospitalization duration(1)	.004	.691	.000	1	.996	1.004
Hospitalization duration(2)	-.493	.670	.542	1	.462	.611
Discharge disposition			11.830	6	.066	
Discharge disposition(1)	1.676	.826	4.116	1	.042	5.342
Discharge disposition(2)	22.308	10366.699	.000	1	.998	4877036073.909
Discharge disposition(3)	4.746	3.552	1.785	1	.182	115.070
Discharge disposition(4)	.969	2.224	.190	1	.663	2.635
Discharge disposition(5)	-16.778	40192.970	.000	1	1.000	.000
Discharge disposition(6)	2.597	.896	8.399	1	.004	13.418
BP			4.199	2	.123	
BP(1)	1.301	.635	4.199	1	.040	3.672
BP(2)	25.028	24543.706	.000	1	.999	74028849642.421
HR.			6.102	2	.047	
HR.(1)	-3.141	1.700	3.414	1	.065	.043
HR.(2)	1.272	.779	2.670	1	.102	3.569
Na			2.324	2	.313	

Na(1)	.969	1.419	.467	1	.495	2.635
Na(2)	-1.027	.783	1.718	1	.190	.358
BUN/Cr			1.854	2	.396	
BUN/Cr(1)	1.292	1.040	1.543	1	.214	3.639
BUN/Cr(2)	.896	1.141	.616	1	.432	2.449
Cr			11.075	2	.004	
Cr(1)	-.311	1.248	.062	1	.804	.733
Cr(2)	2.016	.693	8.462	1	.004	7.509
Hgb(1)	-.598	.581	1.059	1	.303	.550
Pressors required(1)	-.681	2.542	.072	1	.789	.506
Intra Aortic Balloon Pump(1)	40.767	56841.443	.000	1	.999	506772158989469180.000
Tobacco Use			7.070	4	.132	
Tobacco Use(1)	-1.848	.914	4.086	1	.043	.158
Tobacco Use(2)	-.035	.630	.003	1	.956	.966
Tobacco Use(3)	-1.908	1.660	1.320	1	.251	.148
Tobacco Use(4)	-4.021	2.251	3.189	1	.074	.018
AIDS	26.655	23895.083	.000	1	.999	376707060855.558
Alcohol abuse	2.020	5.497	.135	1	.713	7.536
Deficiency Anemias	.542	.747	.526	1	.468	1.719
Arthropathies	-3.616	1.442	6.290	1	.012	.027
Chronic blood loss anemia	1.924	6.860	.079	1	.779	6.851
Leukemia	37.035	46700.500	.000	1	.999	12130545869000848.000
Lymphoma	-3.563	2.111	2.849	1	.091	.028
Metastatic cancer	27.416	23779.443	.000	1	.999	806628941303.526
Solid tumor without	-20.120	23779.443	.000	1	.999	.000

metastasis, malignant						
Cerebrovascular disease - present on admission	2.263	2.197	1.060	1	.303	9.609
Cerebrovascular disease – sequelae	26.912	40192.970	.000	1	.999	487343389861.793
Cerebrovascular disease - sequelae paralysis	2.339	2.321	1.015	1	.314	10.366
Congestive heart failure	-3.053	1.111	7.549	1	.006	.047
CHF with hypertension, complicated	1.479	1.136	1.693	1	.193	4.388
CHF with hypertension w renal failure, severe	4.202	2.084	4.065	1	.044	66.789
Coagulopathy	2.040	1.371	2.214	1	.137	7.690
Dementia	-.529	1.010	.274	1	.601	.589
Depression	.121	.923	.017	1	.896	1.129
Diabetes with chronic complications	-1.130	.675	2.802	1	.094	.323
Diabetes without chronic complications	2.945	1.003	8.631	1	.003	19.019
Drug abuse	1.136	1.326	.733	1	.392	3.113
Hypertension, complicated	-1.509	1.161	1.689	1	.194	.221

Hypertension, complicated with renal failure, severe	-14.252	40192.970	.000	1	1.000	.000
Hypertension, uncomplicated	-.833	.889	.879	1	.348	.435
Liver disease, mild	2.230	2.407	.858	1	.354	9.299
Liver disease, moderate to severe	-1.861	4.643	.161	1	.689	.156
Chronic pulmonary disease	2.357	.690	11.668	1	.001	10.555
Neurological disorders affecting movement	-1.350	1.950	.479	1	.489	.259
Other neurological disorders	-.475	.981	.234	1	.628	.622
Seizures and epilepsy	2.109	1.632	1.669	1	.196	8.238
Obesity	1.037	.597	3.017	1	.082	2.820
Paralysis	2.821	2.902	.945	1	.331	16.801
Peripheral vascular disease	-.289	.948	.093	1	.761	.749
Psychoses	-.096	1.901	.003	1	.960	.908
Pulmonary circulation disease	2.181	1.049	4.318	1	.038	8.854
Renal failure, moderate	.650	.797	.666	1	.415	1.916

Renal failure, severe	.573	1.293	.197	1	.657	1.774
Hypothyroidism	.032	.829	.002	1	.969	1.033
Other thyroid disorders	-1.527	42260.166	.000	1	1.000	.217
Peptic ulcer with bleeding	-1.615	1.620	.994	1	.319	.199
Valvular disease	1.427	.645	4.886	1	.027	4.165
Weight loss	1.917	1.172	2.678	1	.102	6.803
Constant	-5.363	1.896	7.999	1	.005	.005

Appendix A10

Table A8

*Predicted probability * Palliative Care Consult*

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	234.000[a]	232	.451
Likelihood Ratio	313.626	232	.000
N of Valid Cases	234		

a. 466 cells (100.0%) have expected count less than 5. The minimum expected count is .39.

*PVar_Match * Palliative Care Consult*

Chi-Square Tests			
	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	132.000[a]	131	.459
Likelihood Ratio	154.691	131	.077
N of Valid Cases	132		

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