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Discovering Hidden Signs and Symptoms of Heart Failure in the Electronic Health Record Using the Omaha System

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Abstract

Purpose/Background/Significance: For the past 30 years, heart failure has been in the top 3 readmission diagnoses with patients discharged to community care. This is costly to the healthcare system and negatively impacts the patient's quality of life. The purpose of this study is to evaluate a community care database to determine if previously under-considered latent variables exist that could provide early detection of heart failure signs and symptoms. **Theoretical/Conceptual Framework:** The theoretical and conceptual frameworks surrounding this work are the Omaha System and Donabedian's structure, process, and outcomes theory for healthcare quality improvement supported by Neuman's Systems Model. The Omaha System was constructed on the combined basis of these theoretical underpinnings by three components: The Problem Classification Scheme, The Intervention Scheme, and The Problem Rating Scale for Outcomes. **Methods:** This study was a retrospective, descriptive, observational, comparative study using secondary data. Major HF-associated signs and symptoms related to problems of circulation and respiration were queried. Latent Class Analysis (LCA) was used to identify if other significant groupings of signs and symptoms were associated with heart failure signs and symptoms. **Findings:** Evaluation of the sample for signs and symptoms of HF related to the Omaha System Problems of Respiration and Circulation revealed 4215 individuals. LCA revealed four significant groupings of signs and symptoms related to the problems of Mental health, Cognition, Heart failure and General/Other. Further analysis determined that the HF group had the most interventions and visits yet had the lowest change in Knowledge, Behavior, and Status scores indicating that HF required intensive outpatient care to maintain their status in the community care environment

without benefiting from significant final status improvement. Analysis revealed that patients with Cognition group benefited the most from increased visits and interventions.

Conclusion: Patients exhibiting signs and symptoms of heart failure may also experience signs and symptoms of Mental health and Cognition changes, which may either contribute to heart failure exacerbation, or be as a result of the heart failure disease process. Further research is needed to examine possible mechanisms that may help defer HF exacerbations.

Keywords: Heart failure, the Omaha System, signs and symptoms.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

Heart failure is a progressive, chronic disease whose progression can be managed to improve or sustain the patient's quality of life. For the past 30 years, the Medicare 30-day readmission rate for heart failure has hovered around 25% being either the third or fourth leading readmission diagnosis overall (Fingar. Barrett, and Jiang, 2017). This suggests that how the patient is managed in the inpatient environment may or may not be working well in the outpatient community care environment.

Most heart failure patients are medically diagnosed by non-invasive medical testing such as determination of ejection fraction by an echocardiogram, diagnostic laboratory tests such as biomarkers of cardiac activity, and other physiologic indicators. CT scans and MRIs allow providers to see the heart's structures and how well the heart is functioning. If necessary, invasive testing such as cardiac catheterization can be performed to better determine ejection fraction and measure other physiological functions of the heart. However, these tests results will help inform the nurse about the heart failure patient's condition, but by themselves are not nursing-specific signs and symptoms for which a nursing intervention may be initiated.

To discover what may be contributing to the high Medicare readmission rate for heart failure we need to start with looking at the signs and symptoms that are addressed in the hospital to see if they are the same or different than those seen in the community care environment. What signs and symptoms are occurring in the community care environment that contributes to the heart failure patient not successfully managing their chronic illness outside of the hospital environment roughly 25% of the time? Are there other signs and symptoms that occur early in the patient's community care environment

stay that could forego a hospital admission if caught early where treatment is the most effective? If they exist, what are those signs and symptoms? Are they different from the established signs and symptoms of the tools, guidelines, and metrics that currently support and guides heart failure care? Do these established tools, guidelines, and metrics work in the community care environment, or are we missing subtle or hidden critical information that, if known, can be part of a clinical nursing assessment and possible nursing intervention?

To accomplish this, secondary data analysis of signs and symptoms of heart failure combined with the social determinants of health may demonstrate patterns or groupings of individuals with better and worse disease management and response based on their environmental, circumstance, and health statuses. This will be guided by using the Omaha System framework (Martin, 2005).

Statement of the Problem

According to the Centers for Disease Control and Prevention (CDC), heart failure is a chronic, progressive disease where the heart cannot pump enough blood throughout the body efficiently and effectively to support basic life systems (2020). Heart failure affects 6.5 million Americans in 2017, contributing to the cause of death in 1 in 8 deaths and in 2012 dollars cost the nation $30.7 billion in 2012 (CDC, 2020). Part of the high cost of heart failure can be attributed to the fact that it is a chronic and somewhat cyclic disease. Acute heart failure requires hospitalization to diagnose the severity of the heart failure through cardiovascular testing, surgical and non-surgical treatments, prescribing or adjusting cardiac/heart failure medications, controlling diet and exercise, and preparing the patient to be discharged to community care. The problem is managing heart failure

signs and symptoms in the community setting can be ineffective because of patient characteristics, and we do not know all the patterns of signs and symptoms that contribute to the cause or deterioration of heart failure. Earlier detection of disease progression or regression allows providing interventions that may mitigate or lessen the impact of worsening heart failure results in better outcomes and patient quality of life.

Significance of the Problem

The significance of this problem is that despite decades of heart failure research, we still do not have a consensus on which signs and symptoms of heart failure and in what patterns would make managing heart failure patients in community settings the most effective. Recurring hospital readmissions cost the United States healthcare system $30.7 billion for 2012 (CDC, 2020; Casey, 2017; Fingar et al., 2017; Kilgore et al., 2017; McKinley et al., 2019). In 2017, the contributing mortality rate of heart failure was 13.4% (CDC, 2020). Due to the financial implications, the Affordable Care Act (ACA) established the Hospital Readmission Reduction Program (HRRP) in 2012 for readmissions of heart failure within 30 days of discharge (QualityNet, 2019). Hospitals failing to reduce readmission rates for heart failure, myocardial infarction and pneumonia are financially penalized based on a total percentage of Medicare payments. If only 10% of the readmissions could be prevented, Medicare could save $1 billion (Mcllvennan et al., 2015).

The Heart Failure Society of America (HFSA) states that 6.5 million Americans over the age of 20 have heart failure accounting for 8.5 percent of all heart disease-related deaths in the United States (HSFA, 2019). The average life expectancy of heart failure patients is five years for about 50 percent of the diagnosed patients. If heart failure is

severe, only around 10 to 20 percent of patients will be alive after one year of diagnosis (HFSA, 2020). With the "Baby boom" generation aging, the incidence of heart failure will only increase over time. (Colby & Ortman, 2014; Werner, 2011). Furthermore, Heidenreich et al. (2013), state "By 2030, > 8 million people in the United States will have heart failure…and the costs, including indirect costs of heart failure are estimated to increase from $31 billion in 2012 to $70 billion in 2030" (p. 606). According to Johnson et al, (2014), heart disease, of which heart failure is represented, has been the leading cause of death in the United States (23.7% of total deaths in 2011).

Officially, there is no tool comprised of an overarching consensus for what the signs and symptoms are of heart failure within the community care setting. There are multiple metrics, tools, instruments, and guidelines that are used, but they are primarily designed for inpatient or specialty use. There are differences between the tools, with none of them being in complete agreement with one another. Examples of these tools evaluated are the American Heart Association/American College of Cardiology heart failure criterion, the Framingham Criterion for Congestive Heart Failure, the New York Heart Association Functional Capacity Classification, the Seattle Heart Failure Model, and the Stanford Heart Failure dashboard. They are based primarily on expert opinion instead of what EHR data demonstrates, and because they are based on expert opinion, vary greatly on which signs and symptoms that expert feels are the most important or relevant to disease progression. Therefore, measurement consistency is lacking, and full identification of all the heart failure signs and symptoms may not be up to date with the current disease process. In order to determine what is currently the best signs and symptoms of heart failure, particularly those showing in the community care setting,

evaluation of the EHR data would provide the best information to establish those community care setting heart failure signs and symptoms, or groupings of signs and symptoms, criteria.

The justification for investigating patterns of signs and symptoms of heart failure within a community-based EHR is to improve nursing practice through earlier identification of previously unknown patterns or groupings of signs and symptoms. This would help reduce overall costs to the healthcare system and improve the signs and symptoms of heart failure in the community care environment.

Early detection of signs and symptoms of heart failure would lessen the effect of heart failure on the patient both in the time required until treatment starts or is adjusted, and the degree of control needed to restore the patient to heart failure stability minimizing permanent cardiac damage. These factors impact the patient's quality of life. Early detection and treatment are also cost-effective to the health care system lessening the economic burden of costly hospital readmissions. In theory, real-time detection would have the opportunity and greatest ability to shorten both the time to identify new or worsening heart failure and need the least amount of effort to control before disease progression does irreparable damage to the heart. Understanding the pattern or groupings of signs and symptoms that are seen could support using the EHR patient record with real-time analysis to provide immediate feedback regarding heart failure status.

Purpose of this Study

The purpose of this study is to evaluate signs and symptoms of heart failure using the Omaha System by performing secondary data analysis of an existing community setting database to discover patterns of signs and symptoms indicative of heart failure.

The identification of patterns may offer clues earlier in the patient's disease progression, where earlier intervention could have the most significant impact on the patient's outcome. Heart failure is predominately managed in community-based settings, and there is a long history of effective management in nurse-led heart failure clinics (Martinez-Gonzalez et al, 2014; Grange, 2005;). Using the Omaha System as a tool to identify and perform treatments and services, and measure outcomes of these treatments or services on disease progression or patient understanding are vital for assessing patient's needs and guiding the nursing practice of heart failure patients. The data source will be from the Omaha System Partnership and Data Collective at the University of Minnesota Center for Nursing Informatics. It is clinically relevant to recognize all signs and symptoms of a disease process to effectively and efficiently address the disease progression.

Theoretical Framework

The theoretical framework of the Omaha System is considered a middle-range theory that is comprised of and supports the Donabedian's structure, process, and outcomes theory for healthcare quality improvement. It is further supported by the Neuman's Systems Model, which states that the nursing process consists of three consecutive steps: the nursing diagnosis, the nursing goals, and the nursing outcomes. the Omaha System was constructed on the combined basis of these and other theoretical underpinnings and are represented by three components: Problem Classification Scheme, Intervention Scheme, and Problem Rating Scale for Outcomes (Martin, 2005).

The theoretical framework of the Omaha System is particularly important because it is a standardized interface terminology designed to be incorporated with the EHR to allow the sharing of clinical data both within the EHR and through external means to

other clinical systems. the Omaha System is Health Insurance Portability and Accountability Act (HIPAA) compliant, certified by the International Organization for Standardization (ISO), and recognized by the Health Level Seven (HL7®) interphase. (Omaha System, n.d.).

The Omaha System has been extensively studied under four federally funded grants between 1975 and 1993. Its validity, reliability, and usability has been researched as a comprehensive standardized taxonomy that enables the collection aggregation and analysis of clinical data (Omaha System, Overview, 2020).

Research Aims and Questions

Aims and Questions

Aim 1 - Describe demographics, service characteristics, and outcomes of the sample of adults ages 50 and older with one or more signs/symptoms included in the heart failure algorithm.

Question 1.1 – What are the demographics characteristics of this sample?

Question 1.2 – Which of the 42 Omaha System problems were documented for the sample?

Question 1.3 – What were Knowledge, Behavior, and Status scores for the sample?

Question 1.3.1 - What is the frequency of positive change compared to baseline Knowledge, Behavior, Status (KBS)?

Question 1.4 – What service characteristics (interventions and visits) were documented for the sample?

Question 1.5 – What signs and symptoms were documented for the sample?

Aim 2 - Discover groups within the sample described in Aim 1 using latent class analysis (LCA).

Question 2.1 – What are the demographics characteristics of each group?

Question 2.2 – Which of the 42 Omaha System problems were documented for each group?

Question 2.3 – What were Knowledge, Behavior, and Status scores for each group?

Question 2.3.1 - What is the change in Knowledge, Behavior, Status (KBS) per group from admission to discharge per problem?

Question 2.4 – What service characteristics (interventions and visits) were documented for each group?

Question 2.5 – What signs and symptoms were documented for each of the groups?

Aim 3 – Compare service characteristics (interventions/visits) relative to outcomes for each of the groups identified in Aim 2.

Question 3.1 – Which intervention characteristics were associated with the best outcomes overall and by group?

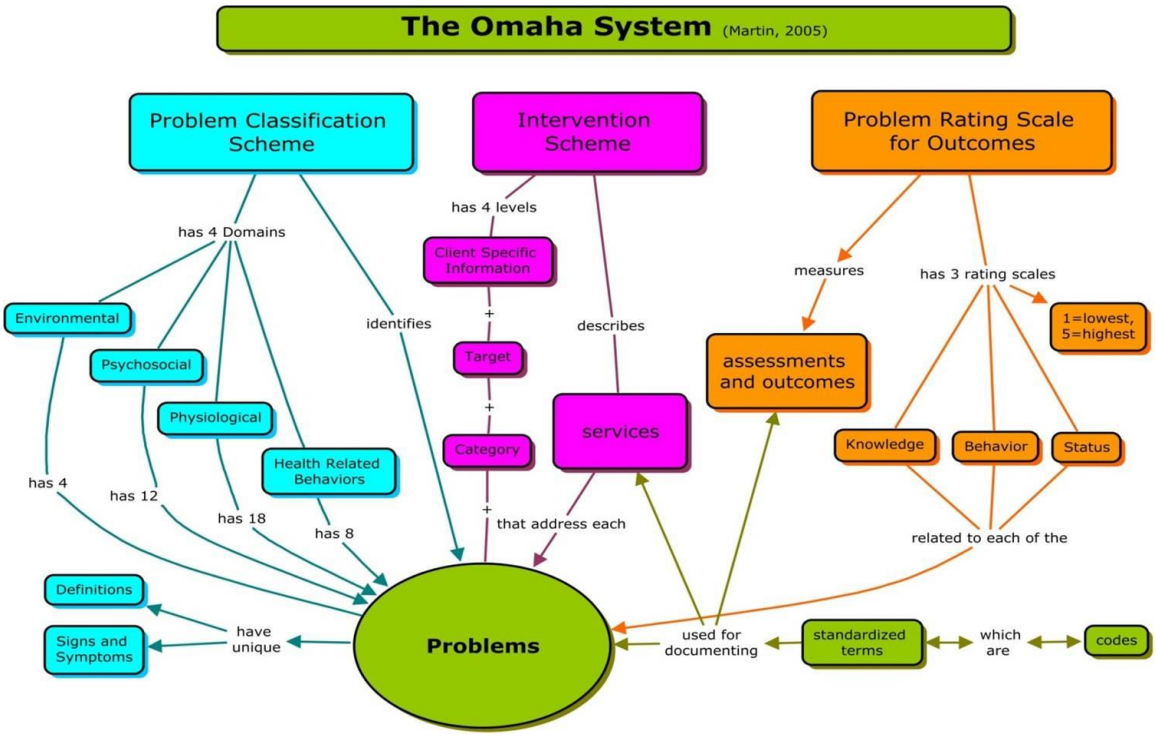
Theoretical Definitions

The Omaha System consists of the Problem Classification Scheme, the Intervention Scheme, and the Problem Rating Scale for Outcomes (Martin, 2005, p. 24).

- Problems are signs and symptoms that describe the client's condition or status. Problems are considered second level at the Problem Classification Scheme (Martin, 2005).
- Interventions are the practitioner's actions or activities that are implemented based on the client's presenting problems or needs used to prevent illness, maintain, or restore health (Martin, 2005). They are used in the Intervention schema.
- Outcomes - The Problem-Related Scale for Outcomes is a comprehensive, systematic, recurring evaluation framework that measures client progress about the specific problem interventions administered to the client. It measures Knowledge, Behavior, and Status (KBS) on a 5-point Likert ordinal scale ranging from 1 to 5 with 1 being the most negative and 5 being the most positive (Martin, 2005; Monsen et al., 2010). See Figure 1.

Figure 1

The Omaha System (Martin, 2005)



Assumptions and Limitations

The first assumption is the Omaha System taxonomy includes signs and symptoms of heart failure in the database as part of its structure. The second assumption is the Omaha System taxonomy was used in this community setting database. The third assumption is that the nurses documenting in this community based EHR were trained both in the use of the Omaha System and the EHR in which it is embedded.

Limitations of this study include that the inability to know where in the heart failure disease process this encounter or encounters occurs is unknown. The original purpose of these community-based encounters is unknown. Another limitation is that there are no medical diagnoses included in the system so you cannot query by heart

failure. All we are able to identify in the data is the Omaha System Problem of Circulation and other problems (Respiration) related to heart failure. The use of this existing database that does not include medical diagnoses, does not allow for a specific design focus for heart failure signs and symptoms.

Summary

It has been difficult for nurses to manage heart failure patients in the community care environment. What has been the accepted signs and symptoms of heart failure may be evolving into more signs and symptoms than previously identified. This retrospective descriptive study on secondary data from the Omaha System Partnership and Data Collective at the University of Minnesota Center for Nursing Informatics will contribute to our understanding of which signs and symptoms are present, and the patterns or groupings of signs and symptoms may be significant in managing heart failure better in the community care settings. This study's significance to nursing is that it will help develop new knowledge that may transform how we manage heart failure patients in the future in the community care environment. Nurses provide much of the direct and indirect community-based care. They must have all the tools necessary to assess a patient's heart failure status alerting the nurse to changes in the patient's condition at an earlier stage, allowing for performing interventions that may lessen the severity and duration of heart failure exacerbation.

The Omaha System taxonomy is an excellent resource to organize and evaluate nursing practice in the community setting. The Omaha System helps to identify the problems, interventions to mitigate the identified problems, and then assess outcomes of the interventions. To help determine if signs and symptoms are forming patterns or

occurring in groupings of other signs and symptoms, secondary data analysis on this community based EHR data using the Omaha System will be performed. It is hoped that this analysis will provide new insights and knowledge into how heart failure is managed in the community-care setting. Potentially this could aid in directing care in the provider based settings as well as the inpatient setting, typically when the initial diagnosis and treatment of acute heart failure occurs. The signs and symptoms that substantiate a heart failure diagnosis need to be evaluated and compared to real-world data such as that in the Omaha System Partnership and Data Collective at the University of Minnesota Center for Nursing Informatics. It is the hope of this researcher to determine if currently accepted signs and symptoms of heart failure are still the appropriate and relevant signs and symptoms or has the disease process expanded such that new signs and symptoms, or specific groupings of signs and symptoms, that are more definitive and suggestive of heart failure or its exacerbation exists. This study will contribute to the science of management of currently diagnosed heart failure patients and improve our understanding of what is currently happening in the community care setting to effectively manage heart failure patients in the future.

To understand which tools, metrics, guidelines, or instruments exist that currently are used to identify heart failure signs and symptoms in the community-based setting, a review of the literature was performed. This literature review will provide the basis of what are the currently accepted signs and symptoms of heart failure and what currently accepted signs and symptoms are not as relevant due to advances in medical research and evidence-based practice-changing what we thought was the gold standard of signs and symptoms of heart failure.

Chapter 2

Literature Review

The purpose of this literature review is to provide a critical review of the literature for Electronic Health Record (EHR) based metrics used to guide nursing assessments, the resultant treatments or interventions, and provide meaningful and measurable outcomes for adult heart failure patients. This literature review focuses on determining if tools, instruments, metrics, or guidelines are being used, which ones are used, and if they can be used by nurses in the community care environment to improve the quality of life for heart failure patients.

This literature review's scope is to determine what tools, metrics, guidelines, or instruments exist to evaluate for signs and symptoms of heart failure. Further examination of these tools, metrics, guidelines, or instruments will be made to determine if any are pertinent and helpful for use in the community care setting. The literature reveals instruments such as the American Heart Association (AHA) Get with the Guidelines Criteria, the Framingham Criterion for Congestive Heart Failure, the New York Heart Association Stages of Heart Failure, the Seattle Heart Failure Model, and the Stanford Heart Failure dashboard are primarily focused on inpatient initial assessments or diagnostics and treatments. These are not designed to guide the treatment of adult heart failure in the community care environment. Furthermore, they are not consistent in which heart failure signs and symptoms are the most important or relevant to the outpatient community care setting. The literature is sparse in its mention of the social determinants of health as contributing factors to heart failure signs and symptoms. Some of the signs and symptoms of heart failure are known, and some may yet be discovered. In order to find the hidden or subtle signs and symptoms of heart failure and the impact they may

have on the condition before hospitalization or on the structural changes occurring within the heart, all patient signs and symptoms need to be evaluated. This will be done by using an established holistic framework that incorporates the physiological signs and symptoms as well as the environmental, psychosocial, and health-related behavior signs and symptoms to evaluate further these aspects that may impact heart failure status more than is currently realized.

This literature review has four sections: 1. Framework: The Omaha System; 2. The Omaha System in research; 3. The review of the heart failure literature using the Omaha System framework; 4. Synthesis of the literature review.

The Omaha System framework was applied to evaluate what was found in the literature.

Conceptual Framework: The Omaha System

To accurately and effectively assess the literature, a framework to guide the literature review was necessary. In reviewing frameworks for this literature review, the Omaha System was determined to be the best to conduct this literature review. The Omaha System is a research-based and standardized hierarchal taxonomic classification system designed to guide clinical practice through logical documentation of initial physiological, environmental, psychosocial, and health-related behaviors which guide interventions that may improve the patient's condition and allow for the evaluation of the quality and outcome of these interventions on the patient's condition. This methodology supports and develops evidence-based practice (Martin, 2005; Omaha System, n.d.).

The Omaha System is considered a holistic, multidisciplinary, standardized terminology, and conceptual framework (Martin, 2005; Monsen et al., 2014) "developed

by nurses and other disciplines to depict a comprehensive, holistic conceptual framework for health in the context of environment and relationships" (Monsen et al., 2014, p. 300). Through its categorization process, the Omaha System is also an ontology. An ontology is a formal description of knowledge as a set of concepts within a domain and the relationships that hold between them that ensures a common understanding of information (Ontotext, 2019). Ontology is also described as a "formal framework that describes anything (not just a taxonomy) by establishing the classes that identify how to create hierarchical (and quasi-hierarchical) taxonomies" (Cagle, 2019). The use of the Omaha System as an ontology serves as a "theory-terminology bridge that can link philosophy and science and provide a foundation for Big Data analysis" (Monsen, 2018b, p. 113). According to Monsen (2018b), the Omaha System was designed to be used in all disciplines, including consumers, to evaluate health comprehensively and allow for ontological-based text mining capabilities within EHRs.

The Omaha System consists of four domains: Environmental, Psychosocial, Physiological, and Health-Related Behaviors. These domains contain 42 problem defining concepts. For example, the Physiological domain contains all the major body systems such as Circulation, Respiration, and Digestion-Hydration. Within each of these categories are problems defined by actual signs and symptoms that the client may present. Interventions appropriate to the problems would be applied. There are four categories of interventions:

1. Teaching, guidance, and counseling
2. Treatments and procedure
3. Case management

4. Surveillance

These interventions are designed "to develop a care plan defined as a set of anticipated interventions and to document health-related actions that were provided" (Martin, 2005, p. 42). The Problem Rating Scale for Outcomes is a 5-point Likert scale, one being worse than five, ranking the patient's knowledge, behavior, and status (Martin, 2005). This rating scale allows practitioners to assess the effectiveness of their interventions, for substantiating clinical improvement, and data collection. If the patient does not improve, a different intervention may be employed, or the justification for hospitalization of the patient will now exist.

The specificity and all-encompassing nature of the Omaha System lends itself well to supporting the data aggregation needed to support clinical outcomes. It is actively being used as an ontological framework in research to map other model's descriptive phrases to form a linkage between the investigative model and the Omaha System.

Use of the Omaha System in Research

Gao et al., (2018) used the Omaha System to match the Problem Classification scheme to the Wellbeing Model dimensions. In evaluating The Wellbeing Model for older adults, particularly those residing in assisted living facilities, six dimensions are used that provide the "contextual meanings that contributed to the makings of an individual's wellbeing," namely Community, Environment, Health, Purpose, Relationships, and Security (Gao et al., 2018). Doing so allowed the researchers to analyze signs and symptoms and identify any undiscovered signs and symptoms that may contribute to patients not achieving well-being with their chronic diseases. From this study using the Omaha System as the theoretical and operational framework, Gao et al.,

found that of the six dimensions, resident strengths and wellbeing outnumbered signs and symptoms except in the Health dimension where more signs and symptoms were apparent. They concluded that based on these results, focused healthcare resources on these older adults help to manage the healthcare resources as well as improve health outcomes (Gao et al., 2018).

In 2018, Monsen et al., evaluated the feasibility of "using an ontology-based structured text mining approach based on the Omaha System with CaringBridge social media journal text data" (p. 228). One of the issues they encountered included the variability and complexities of language, lending useless standard data extraction algorithms. They employed the Omaha System ontology as a human-computer interface to describe health and social needs and interventions that existed in the social media data (Monsen et al., 2018). Their findings suggest that an ontology-based approach reveals not only the obvious and relevant data but will also allow for less obvious yet still relevant and important information about the patient's condition to be revealed (Monsen et al., 2018). This function of discovering hidden, or seemingly not as important, information may indeed impact the patient's condition. The use of an ontological based holistic structure allows the subsequent algorithmic query analysis to reveal "hidden" data impacting the patient's health and wellbeing that may have been undiscovered if it had not been available for data extraction.

In their 2014 article examining the feasibility of using the Omaha System to capture self-reported strength phrases, Monsen et al., "used the Omaha System Problem Classification Scheme as a mapping framework to provide taxonomic structure for self-reported natural language strengths phrases" (p. 302). From the data abstraction, the

researchers were able to perform descriptive and exploratory analyses of the strengths by the Omaha System domain (Monsen et al., 2014). This research demonstrated that the Omaha System could function not only as a problem-based ontology but as a strength-based ontology to support "the national movement in health care away from a problem-focused model of care" (Monsen et al., 2014, p. 313).

The results of these publications indicate that the Omaha System is an effective, efficient, and easy to use ontological framework that is capable of being implemented within EHRs. Considering the existing multifactorial signs and symptoms of heart failure that are present when heart failure patients are evaluated or assessed, a holistic and comprehensive ontology ensures that all aspects of the human condition are included in the evaluation. This potentially may identify unknown signs and symptoms which may be contributing to heart failure decline. In order to accomplish this holistic and comprehensive evaluation, the Omaha Systems is the framework used for this literature review.

The Evaluation of the Literature using the Omaha System Framework

Methods

Search Strategy

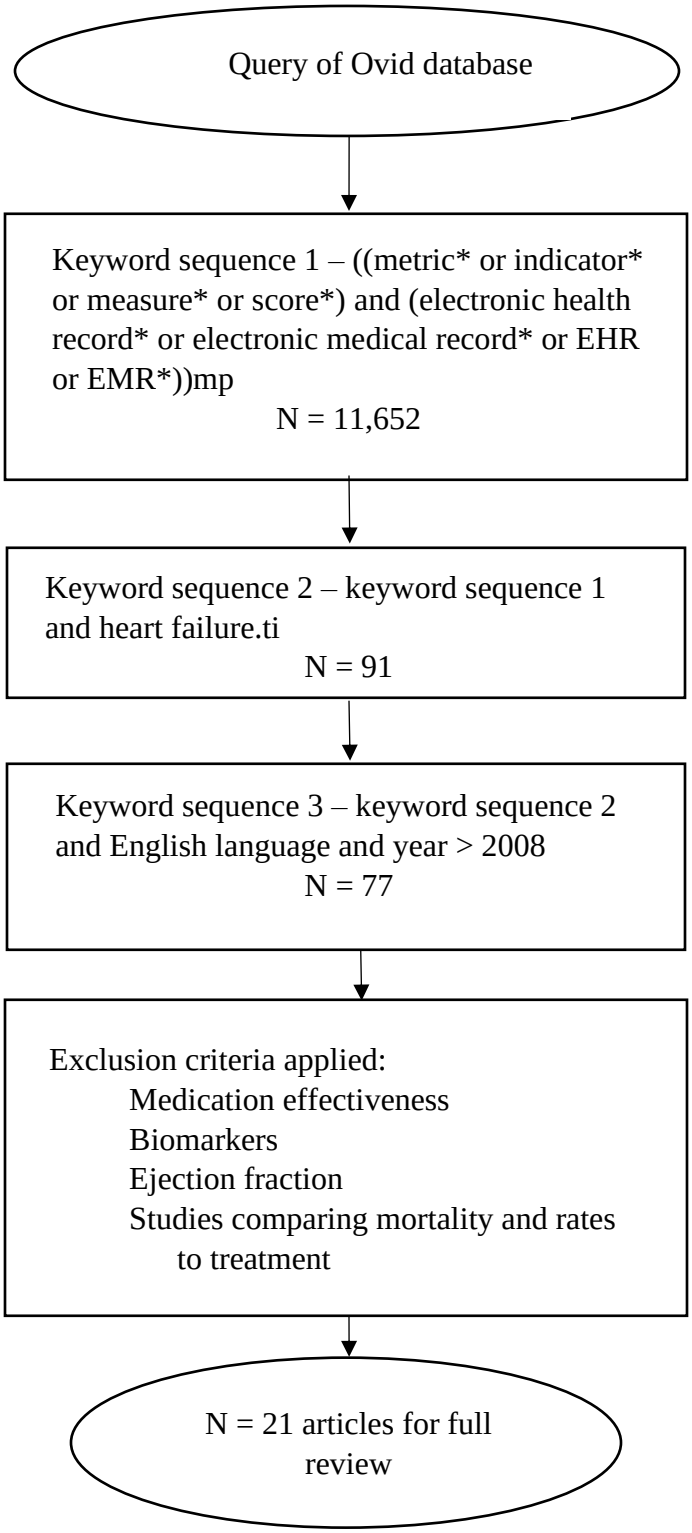
The Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009) guidelines were followed for this literature review. The Prisma checklist adopted the definitions developed by the Cochrane Collaboration and the existing QUOROM (Quality of Reporting Meta-analyses) checklist as a method to improve the quality of systemic literature reviews, which varied greatly in reporting quality thus limiting the reliability on the information presented in the reviews.

In 2005, The PRISMA group of review authors, clinicians, methodologists, medical editors, and a consumer met in Ottawa, Canada; existing guidelines were updated to the 27-point PRISMA checklist and flow diagram (Moher et al., 2009). This checklist and flow diagram support the systematic review of the literature used to perform this review.

The OVID database was the source of this literature query. The first query line keywords used were: Heart failure, EHR, EMR, Electronic Health Record, Electronic Medical Record, tool, metric, instrument, and score. Second-line keywords used were the English language and 2008 forward. The query was performed on May 7, 2019. The Ovid database query resulted in 77 articles. There were no duplicate articles. The exclusion criteria of medication effectiveness, biomarkers, and ejection fractions were applied, resulting in 21 articles that were fully reviewed. See Figure 2.

Figure 2

Prisma diagram of Ovid database search



Data Analysis

A data abstraction tool was created in Microsoft Excel 2016 derived from the literature and clinical expert consensus. The Omaha System was used to analyze the literature identified. Thirty-five Omaha System Problem signs and symptoms of heart failure were identified. The list of 21 articles were placed vertically in the first column of the worksheet. Related publication information regarding the journal, year of publication, and strength of evidence, and full APA reference information were placed horizontally in subsequent columns. Omaha System Domains were placed in row 2, and the Omaha System Problem Classifications were placed on Row 3, under their respective domains. For example, row 2 contained the Physiological Domain, and under this domain heading were Cognition, Respiration, Circulation, Digestions, and Urinary function. The actual signs and symptoms were put in the columns in row 4 directly under their respective Problem Classification, forming a hierarchical representation of the signs and symptoms within the constructs of the Omaha System. Figure 3 is a small sample of the actual Excel workbook used for the literature review.

Figure 3

Excel workbook analysis of signs and symptoms

Col-64	Col-65	Col-66	Col-67	Col-68	Col-69
Physiological	Physiological	Physiological	Physiological	Physiological	Physiological
Circulation	Circulation	Circulation	Circulation	Circulation	Circulation
S&S - Edema	Desc - Edema	S&S - Syncopal episodes (fainting)/dizziness	Desc - Syncopal episodes (fainting)/dizziness	S&S - Abnormal Blood Pressure Reading	Desc - Abnormal Blood Pressure Reading
1	edema			1	Systolic and diastolic blood pressure

Literature Review Findings and Results

The most common signs and symptoms associated with heart failure are dyspnea, tachycardia (rapid heart rate above normal), bradycardia (slower than normal heart rate), weight gain (plus or minus 4 pounds in a day), generalized and exertional fatigue, abnormal blood pressure, anginal pain, irregular heart rate, exercise intolerance, and syncope (AHA, 2019). More recent research has also found depression, suicidal/homicidal thoughts, diminished judgment, and limited recall of recent events as consequences of heart failure (Mbakwem et al., 2016; Liu et al., 2018) may contribute to diminished cognitive or functional ability to comply with medication instructions, patient self-monitoring such as daily weights, and ability to recognize the signs and symptoms of deterioration.

Each of the 21 articles meeting the criteria for full review were read and evaluated as to whether the article used a tool, instrument, guideline, or metric to evaluate HF signs and symptoms within an EHR. Signs and symptoms are defined and used in this literature review as those signs and symptoms typically observable and measurable during an assessment or observation. Seven tools, instruments, guidelines, or metrics were found in the reviewed literature related to the identification of signs and symptoms of heart failure within an EHR. They are the New York Heart Association (NYHA) Functional Classifications (Smets et al, 2018; Cully et al., 2009; Zan, 2015), the Framingham Criterion for congestive heart failure (Byrd et al., 2014), the American College of Cardiologists (ACC) and AHA guidelines (Walsh et al., 2012; Meystre et al., 2017), the Minnesota Living with Heart Failure Questionnaire (MLHFQ) (Zan et al., 2015), the Kansas City Cardiomyopathy Questionnaire (KCCQ) (Thompson et al., 2015), the Seattle

Heart Failure Model (SHFM) (Panahiazar et al., 2015, Banerjee et al., 2017), and the Tabak score (Amarasingham et al., 2013).

The tools, instruments, guidelines, and metrics are divided into two major categories. There are the clinical decision support guidelines and those that are centered around patient-reported outcomes (PRO). The clinical decision support guidelines are designed to include evidence-based recommendations on laboratory values, medication regimens, parameters related to testing to confirm or refute the degree of heart failure, and recommendations on what additional medications, treatments, and procedures should be instituted to stop disease progression. The NYHA, AHA/ACC, Framingham, and Seattle are clinical decision support tools, instruments, guidelines, and metrics to gauge them. The PRO are used for assessing heart failure specific to the patient's quality of life (Yee et al., 2018). The patient reported outcome tools, instruments, guidelines, and metrics found in this literature review were the Minnesota Living with Heart Failure Questionnaire (MLHFQ) and the Kansas City Cardiomyopathy Questionnaire (KCCQ). See Table 1.

Table 1

Tools, instruments, guidelines, and metrics by type

Clinical Decision Support	Patient Reported Outcomes (PRO)
American Heart Association (AHA)/ American College of Cardionoly (ACC)	Kansas City Cardiomyopathy Questionaire (KCCQ)
Framingham Criterion For Congestive Heart Failure	Minessota Living with Heart Failure (MLHFQ)
New York Heart Association NYHA	
Tabak score	
The Seattle Heart Failure Model	
The Stanford Heart Failure Dashboard	

The NYHA heart failure stages and functional classifications has four functional (objective) classifications class I, class II, class III, and class IV, and four heart failure stages which increase in severity from Stage A to Stage D. Class I (mild) is mild cardiac disease without symptoms of exertional fatigue, palpations, dyspnea or anginal chest pain that interferes with daily living. Class II (mild) have slight limitations upon ordinary physical activity because it results in fatigue, palpation, dyspnea, and anginal pain. Class III (moderate) patients have marked limitations of normal activity due to resulting fatigue, palpitation, dyspnea, or anginal pain. Class IV (severe) with the inability to perform any normal activity without discomfort. Symptoms of fatigue, palpitations, anginal pain, and dyspnea are present even if the patient is resting. Increasing physical activity increases symptoms and discomfort. The signs and symptoms in this classification are dyspnea, fatigue, limitations on physical activity, anginal pain, and palpitations (AHA, 2019).

The ACC/AHA heart failure stages are also based on objective evidence. Stage A is the presence of heart failure risks factors but no heart disease and no symptoms. Stage B, heart disease is present, but there are no symptoms (structural changes in heart before symptoms occur). Stage C, structural heart disease is present, and symptoms have occurred. Stage D, presence of advanced heart disease with continued heart failure symptoms requiring aggressive medical therapy (AHA, 2019; Yancy et al., 2013; Yancy et al., 2017).

The NYHA and AHA/ACC guidelines are very similar. What differentiates them is that with the AHA/ACC classifications, once you have attained a certain severity of illness level such as level B, which is worse than level A, you do not go back to level A

because irreversible structural cardiac changes have taken place. In the NYHA classification, if your heart failure condition improves, you may be able to revert back to a level of less disease severity (Healio, 2019).

The Framingham Criterion for congestive heart failure major symptoms of heart failure include neck vein distention, paroxysmal nocturnal dyspnea or orthopnea, rales, S3 gallop, and a weight loss of 4.5 kg in 5 days due to the initiation of diuretic therapy. Minor symptoms include ankle edema, night cough, dyspnea on exertion, and tachycardia (Mahmood & Wang, 2013).

The Seattle Heart Failure Model, developed at the University of Washington, is a web-based survival rate score based on the computation of 14 continuous variables and 10 categorical values (Levy et al., 2006) but does multifactorial analyses of multiple databases to develop the predicted survival rate. Its use as a tool for analysis of a heart failure patient's current signs and symptoms to predict heart failure deterioration would be limited. However, if enough data were available to enter into the web-tool, such as medications prescribed, it would provide a survival score for 1, 2, or 3 years from the current evaluation (Levy et al., 2006).

The Kansas City Cardiomyopathy Questionnaire and Minnesota Living with Heart Failure Questionnaire are two of the most widely used PRO for heart failure (Yee et al., 2018). These questionnaires ask the patient about aspects of their life that may be impacted by worsening heart failure and resultant symptomatology. They are designed to identify the impact of heart failure symptomatology on the patient's quality of life and activities of daily living, such as their ability to walk without stopping to catch their breath or how fatigue has been a factor in their ability to enjoy activities. They also

include questions related to housing, income, ability to get food, transportation, and the ability to participate in social interactions, all of which may affect the patient's responses to the heart failure treatment. For example, if the patient has insufficient income to afford the recommended medications, symptoms will present when the patient can no longer afford to refill the prescriptions. If the patient has inadequate housing, the ability to rest, nourish, and take care of the body may be compromised. The signs and symptoms related to housing, income, food and medication availability, transportation, and community access are referred to as the Social Determinants of Health (SDOH). The role SDOH may have on a heart failure patient's disease progression may be more significant than what is currently appreciated or recognized. However, if practitioners do not ask these direct questions, voluntary information regarding housing, income, transportation, and availability to access healthy food and clean water may go unidentified and unassisted. That is why the questions the Kansas City Cardiomyopathy Questionnaire and the Minnesota Living with Heart Failure Questionnaire are essential to ask.

The Minnesota Living with Heart Failure Questionnaire (MLHFQ) identifies 21 heart failure signs and symptoms of edema, fatigue, sleep disturbances, dyspnea, cognition, depression, social interaction, economic impact, and strain on family and friends, ranking the severity of the signs and symptoms on a 5-point Likert scale from minimal impact to very much. Compared to the other metrics, the Minnesota Living with Heart Failure Questionnaire asks more questions regarding the quality of life the patient with heart failure is experiencing.

The Kansas City Cardiomyopathy Questionnaire (KCCQ) is a 15 question, with multiple sub-questions, patient survey of heart failure symptoms measured by a 5 to 6-

point Likert scale per question ranging from extremely limiting to limited for other reasons or did not do the activity. The questions asked the patient to compare their current symptoms to how they were two weeks ago on a separate 6-point Likert scale ranging from 'much worse' to 'I have had no symptoms over the last two weeks.' The questions include the impact on activity levels including household chores, ability to participate in recreational activities, visiting friends out of your home, intimate relationships with loved ones and assessment of mood (Green et al., 2000).

Both the MLWHF and KCCQ questionnaires are true to their origins as PRO. Instead of being clinically based, PRO questionnaires reflect the patient's experience with heart failure symptoms and the impact those signs and symptoms are having on the patient's heart failure status and quality of life. The ultimate goal of chronic disease control is to find the delicate balance between improving the quality of life and controlling disease progression.

The tools, instruments, guidelines, and metrics related to the Omaha System

These seven tools, instruments, guidelines, or metrics were evaluated and found to match 21 signs and symptoms within seven Omaha System Problem classifications. They were circulation (n = 7), respiration (n = 4), mental health (n = 4), cognition (n = 3), communication with community resources (n = 1), physical activity (n = 1), and sleep and rest patterns (n = 1). Actual patient weight, which is not a direct Omaha System Problem associated with the signs and symptoms of heart failure, was identified in the literature as a significant sign and symptom of worsening heart failure and was counted (n = 1). The total number of signs and symptoms discovered is 22.

Articles by Signs and Symptoms

The most frequent sign and symptom found in the literature was abnormal blood pressure reading (n = 14). The articles referring to abnormal blood pressure reading were Blecker et al., (2016); Carvalho et al, (2009), Choi et al., (2017), Conrad et al., (2018); Franchini et al., (2018); Maddocks et al., (2010); McKinley et al., (2019); Munoz et al., (2015); Panahiazar et al., (2015); Radhakrishna et al., (2013); Walsh et al., (2012); Sideris et al., (2015); Smets et al., (2018) and Zan et al., (2015). Blecker et al., (2016) used EHR extracted clinically relevant structured variables but no specific tool. Carvalho et al., (2009) used the NYHA tool. Choi et al., (2017) used the Stanford Heart Failure Dashboard. Conrad et al., (2018) did not use a tool but performed an observational method of extracting routinely collected health data based on the United Kingdom quality of care management programs. Franchini et al., (2018) used the CARPEDIEM Algorithm with external validation by the NYHA II-IV severity index. Maddocks et al., (2010) used Congestive Heart Failure flow sheets based on the Canadian Cardiovascular Society's consensus guidelines. McKinley et al., (2019) used machine learning tools algorithms with no mention of guidelines used. Munoz et al., (2015) extracted patient data based on the International Classification of Disease version 9 (ICD 9) diagnosis code set, value(s) 428.XX and International Classification of Disease version 10 (ICD 10) value(s) of I50.XXXX. Panahiazar et al., (2015) used the Seattle Heart Failure Model. Radhakrishna et al., (2013) did not state what guidelines or tool was used to perform their descriptive statistics query. Walsh et al., (2012) used the ACC/AHA IMPROVE HF guidelines implemented within an EHR based on cardiology practices. Sideris et al., (2015) used the Charlson and Elixhauser's Comorbidity Index. Smets et al., (2018) used the NYHA

guidelines. Zan et al., (2015) used a framework based on the NYHA guidelines and the Minnesota Living with Heart Failure Questionnaire (MLHFQ).

The second most frequent sign and symptom was excessively rapid heart rate (n = 8), found under the Omaha System Circulation domain (Sideris et al., 2015; Munoz et al., 2015; Byrd et al., 2014; Radhakrishna et al., 2013; Walsh et al., 2012; Maddocks et al., 2010; and Carvalho et al., 2009). Bryd et al., (2014) used the Framingham Heart Failure diagnostic criteria. Walsh et al., (2012) used the New York Heart Association functional classes adapted in the IMPROVE HF EHR implementation. Sideris et al., (2015) used the Charlson and Elixhauser's Comorbidity index. The remaining articles used various scales and instruments such as the Borg Scale, which measures oxygen consumption during exercise to determine cardiac reserve. One of the Borg Scale's symptoms was increased heart rate.

The third most common sign and symptom found was excessively slow heart rate (n = 7). The articles referring to slow heart rate were (Cully et al., 2009; Sideris et al., 2015; Munoz et al., 2015; Byrd et al., 2014; Radhakrishna et al., 2013; Walsh et al., 2012; Maddocks et al., 2010; Carvalho et al., 2009). Bryd et al., (2014) used the Framingham Heart Failure diagnostic criteria. Walsh et al., (2012) used the New York Heart Association functional classes adapted in the IMPROVE HF EHR implementation. The remaining articles used a variety of EHR database extractions. Maddocks et al., (2010) extraction was based on the Canadian Cardiovascular Society's consensus guidelines. Radhakrishna et al., (2013) used EHR database queries of patient characteristics.

There were five each signs and symptoms found of actual patient weight (n = 5) and abnormal breath sounds – Dyspnea (n = 5). Actual patient weight was referenced in Zan et al., (2015); Munoz et al., (2015); Byrd et al., (2014); Radhakrishna et al., (2013); and Maddocks et al., (2010). The tools, instruments, metrics, and guidelines used have been previously mentioned.

Articles referencing abnormal breath patterns – dyspnea (n = 5) include Smets et al., (2018); Shao et al., (2016); Thompson et al., (2015); Byrd et al., (2014); and Radhakrishna et al., (2013). Shao et al., (2016) used the MALLET package to extract text from the EHR clinical documentation relating this information to the Charlson Comorbidity Index (CCI). The CCI is a "weighted index to predict the risk of death within one year of hospitalization for patients with specific comorbid conditions." (National Cancer Institute [NCI], 2019). This index was intended to be used in longitudinal studies for development and validation of predictive value of the comorbid conditions on survivability (NCI, 2019).

The sixth most common sign and symptom was edema (n = 3). Articles referencing edema as a contributing sign and symptoms of heart failure include Smets et al., (2018); Byrd et al., (2014); and Walsh et al., (2012).

Five signs and symptoms were referenced by two articles each. They are inappropriate type/amount of exercise for age/physical condition, irregular heart rate, abnormal breath sounds – rales, somatic complaints – fatigue, and loss of interest/involvement in activities/self-care. Inappropriate type/amount of exercise for age/physical condition was referenced by Smets et al., (2018) and Zan et al., (2015). Irregular heart rate was referenced by Cully et al., (2009) and Conrad et al., (2018).

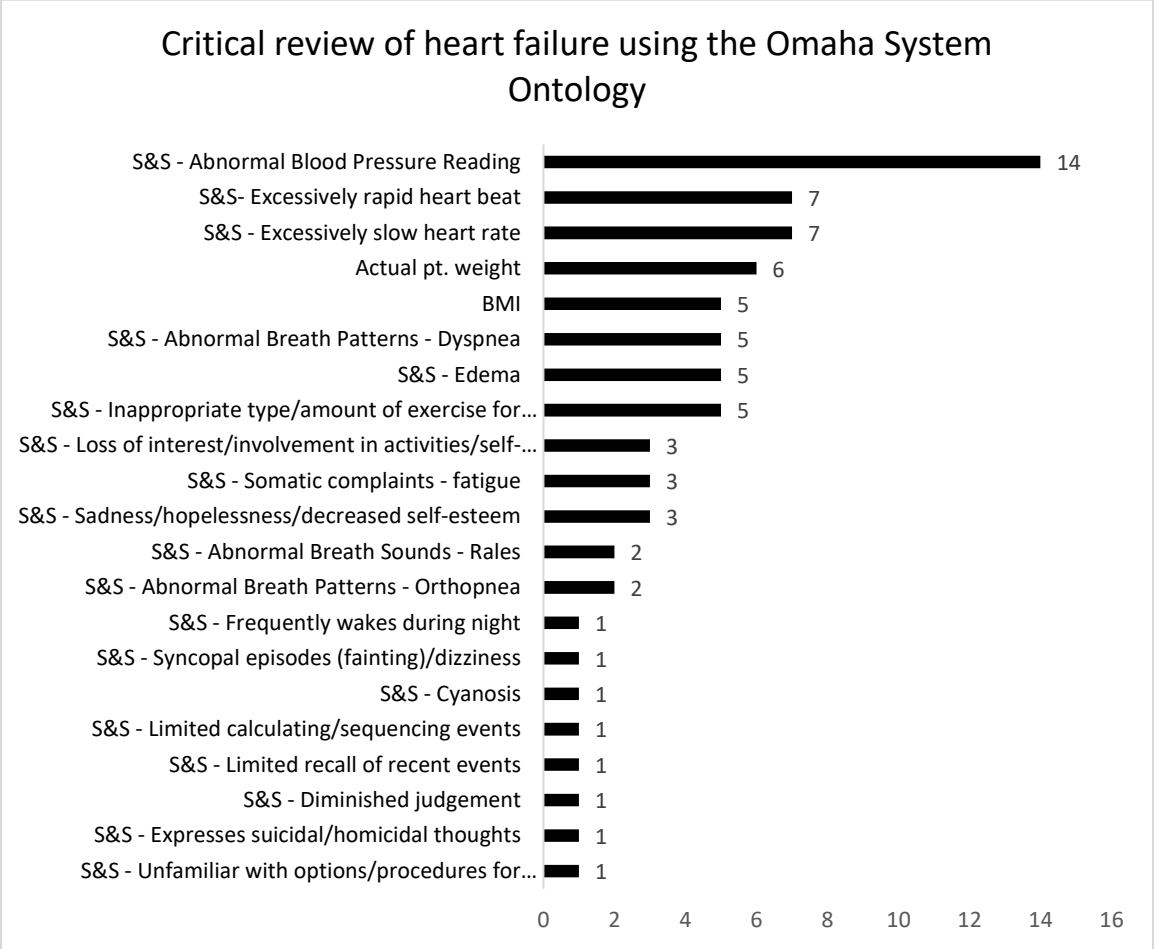
Abnormal breath sounds – rales were referenced by Byrd et al., (2014) and Walsh et al., (2012). Somatic complaints – fatigue was referenced by Shao et al., (2016) and Thompson et al., (2015). Loss of interest/involvement in activities/self-care was referenced by Smets et al., (2018) and Thompson et al., (2015).

Eleven signs and symptoms were referenced by one article each. These signs and symptoms are: frequently wakes during the night, (Zan et al., 2015); anginal pain, (Smets et al., 2018); syncopal episodes (fainting)/dizziness, (Amarasingham et al., 2013); cyanosis, (Radhakrishna et al., 2013); abnormal breath sounds – orthopnea, (Bryd et al., 2014); limited calculating/sequencing events, (Shao et al., 2016); diminished judgment, (Shao et al., 2016); expresses suicidal/homicidal thoughts, (Thompson et al., 2015); sadness/hopelessness/decreased self-esteem, (Thompson et al., 2015); and unfamiliar with options/procedures for obtaining services (Thompson et al., 2015). Amarasingham et al., (2013) used an electronic predictive model, “the e-Model,” measuring the intensity of care transition interventions as their signs and symptoms of heart failure tool.

The summary of these findings is diagramed in Table 2.

Table 2

Number of signs and symptoms found during the critical review of heart failure signs and symptoms using the Omaha System Ontology



Note: Actual patient weight was the actual measurement to ascertain 2 - 4-pound daily weight gain indicating fluid retention. BMI was calculated using actual patient weight as part of the BMI calculation.

Literature Review Conclusion

No single metric found in the literature listed or utilized all of the 18 signs and symptoms found in the 21 articles. The results of this review indicate that a comprehensive, evidence-based metric for the clinical prediction of heart failure-related deterioration, inclusive of patient weight, could be developed utilizing the Omaha System as the framework and ontology. Observation for heart failure signs and symptoms along with patient responses to the SDOH questions could be algorithmically run in EHRs to

give real-time heart failure status to community care providers addressing status deterioration, or the potential for status deterioration, accurately and timely to address increasing signs and symptoms of heart failure before hospitalization is required.

Risk of Bias Within Studies

Recent research into algorithmic bias "reproducing racial and gender disparities via the people building them [algorithms] or through the data used to train them [algorithms]" has shed light on the possibility that the algorithms currently in use for health care analytics and model predicting, may be biased from the point of data extraction (Obermeyer et al., 2019, p. 447). This could explain why current HF treatment guidelines do not work as effectively on women and African American's. Many of the HF studies conducted in the 1950s into the current day, forming the basis of today's inpatient treatment guidelines, were based on the interventions and outcomes of white males. With the morbidity and mortality rates of African American men with HF being significantly higher, the disparity may be a result of algorithmic bias.

Obermeyer et al., (2019) described the use of algorithms in healthcare as assuming the group of patients with the greatest needs will benefit the most from what the designed algorithm finds. Instead of looking at what the current data reflects, the algorithms rely on past data to predict future needs, thus allowing algorithmic bias to enter the equation. This emphasizes the importance of being mindful of bias during algorithm development as the intent of the algorithm should not be to predict what patients will do based on past data but to look for patterns and changes in these patterns in the current data indicating a totally different outcome is occurring particularly as the numbers of our population races and ethnicities evolve.

The concern of algorithmic bias must be thoughtfully and carefully considered when creating an algorithm to query health sensitive data. It also raises the question, how much of previous research on HF is biased against women and African Americans? Might other populations be excluded from targeted disease care and management on their ethnicity, race, or gender? Did I miss anything? Am I unintentionally excluding a population or just not asking an all-inclusive question? Careful, open-ended questions of the data must be asked when evaluating for positive results. Equally as important, we need to look at the negative results and ask ourselves, why?

Synthesis of the Evidence and Results

No tool, guideline, metric, or instrument dedicated to the seven major signs and symptoms, and patient weight, identifying worsening HF for the community care provider was identified. While inpatient tools, guidelines, metrics, instruments, and scores are many and available for guiding inpatient diagnosis and care, there remains a gap in the availability of an EHR based tool, metric, guideline, instrument, or score that is all-encompassing of the needs of the community care providers. This gap between the clinical decision support guidelines that typically do not include the SDOH questions or assessment of the other associated signs and symptoms that may be impacting the patient's health, as evidenced by the existence of the PRO questionnaires, continues failing to meet the needs of the community care providers who have the ability to identify potential issues or decline and intervene earlier when efficacy is higher.

Because heart failure patients may have unrecognized cognitive changes or feel embarrassed about answering questions about income, ability to afford medication, food, or living expenses, it is important that a nurse, physician, or other qualified health care

professional conduct the initial assessment interview using the Omaha System problem lists incorporating and emphasizing other signs and symptoms such as mental and cognitive changes or issues related to the SDOH. It is also incumbent on the heart failure patient to honestly and accurately answer the provider's questions to identify the causative issues and address them efficiently and effectively.

The Omaha System is an American Nurses Association (ANA) approved research-based ontology and meta-model for health and healthcare (Monsen et al., 2018) Using the Omaha System embedded within EHRs could provide the structure for Big Data to work off of to provide support for, refute, or create evidence-based practice guidelines for heart failure signs and symptoms in the community care environment using the seven major signs and symptoms revealed in the literature review. The recent emphasis on addressing the SDOH is already in the Omaha System framework and could be easily incorporated into any algorithm developed and incorporated into the EHR.

In the inpatient environment, nurses educate patients regarding their disease process, medication uses and times to take, activity levels, diet, and when to call their primary care provider (PCP) or cardiologist. We, nurses, hand them a fistful of papers at discharge, instructing them to contact their PCP or cardiologist for a post-hospitalization follow-up appointment, when to call the community care provider, and a summation of the patient education activities provided during their hospitalization. They are primarily discharged to home where self-care management is required. If there is a misunderstanding of directions, inability to access appropriate food, medications, transportation services, or any one of many aspects of this transition to the community care environment which is not quickly identified, patient symptomatology deterioration

occurs as evidenced by the 2014 data of 7-day admission rate of 7.4 percent and a 23.2 percent 30-day readmission rate for HF patients (Fingar & Washington, 2015).

Limitations

Limitations of this systematic review was to discover if any metric, tool, questionnaire, or guidelines specific to heart failure without mention of pre-existing co-morbidities existed that would be relevant for the community care setting. The inclusion of co-morbidities may have had an impact on the number and quality of articles to consider for inclusion. By scoping the key words to heart failure and excluding the testing and medications components which can only be detected by specific tests and prescriptions, it was hoped that a sign and symptom-based metric indicating a worsening heart failure condition observable by nursing assessment or examination would be found. By using data points recorded in the EHR by this symptom-based metric and creating an EHR algorithm used for analyses and prediction would be helpful in early sign and symptom identification of heart failure. It was felt that including studies comparing mortality rates to treatment would not clearly identify early signs and symptoms of heart failure, thus limiting the effectiveness of the primary subject matter of morbidity factor in these articles on the desired outcome of this literature review. Further limitations include the use of only one database to search.

Conclusions

There was not one instrument, tool, metric, or guideline that was all-encompassing of the most frequent cardinal signs and symptoms of heart failure; abnormal blood pressure, excessive and slow heart rate, edema, dyspnea, edema, and

changes in patient's weigh of +/- 4 pounds, indicative of early-stage worsening heart failure where intervention and treatment are most effective.

Chapter 3

Methodology and Procedures

The purpose of this chapter is to describe the methods and procedures that will be used to conduct this study. Descriptions of the variables, method and a plan for data analysis will be discussed. The framework supporting this study, the Omaha System, will be described in detail. The purpose of this study section is to develop and apply a heart failure algorithm that will enable evaluation of group heterogeneity and intervention-related outcomes.

Setting

The setting for this study is the database within the Omaha System Partnership and Data Collective at the University of Minnesota Center for Nursing Informatics. This database contains the demographic and de-identified patient clinical Omaha System data including client problems, signs and symptoms, interventions, and knowledge, behavior, and status outcomes of over 111,000 patient encounters in the community care environment utilizing an EHR (University of Minnesota School of Nursing Omaha System Partnership, 2020). As such, this data is categorical, observational, and descriptive in nature.

Aims and Questions

Aims and Questions

Aim 1 - Describe demographics, service characteristics, and outcomes of the sample of adults ages 50 and older with one or more signs/symptoms included in the heart failure algorithm.

Question 1.1 – What are the demographics characteristics of this sample?

Question 1.2 – Which of the 42 Omaha System problems were documented for the sample?

Question 1.3 – What were Knowledge, Behavior, and Status scores for the sample?

1.3.1 What is the change in Knowledge, Behavior, Status (KBS) from admission to discharge per problem?

Question 1.4 – What service characteristics (interventions and visits) were documented for the sample?

Question 1.5 – What problems/signs and symptoms were documented for the sample?

Aim 2 - Discover groups within the sample described in Aim 1 using latent class analysis (LCA).

Question 2.1 – What are the demographics characteristics of each group?

Question 2.2 – Which of the 42 Omaha System problems were documented for each group?

Question 2.3 – What were Knowledge, Behavior, and Status (KBS) scores for each group?

2.3.1 What is the change in Knowledge, Behavior, Status (KBS) per group from admission to discharge per problem?

Question 2.4 – What service characteristics (interventions and visits) were documented for each group?

Question 2.5 – What signs and symptoms were documented for each of the groups?

Aim 3 – Compare service characteristics (interventions/visits) and outcomes for each of the groups identified in Aim 2.

Question 3.1 – Which intervention characteristics were associated with the best outcomes and overall by group?

Study Design

Setting

Data were generated through routine documentation in community care settings.

Design

This study will be a retrospective, descriptive, observational, comparative study using latent class analysis based on a heart failure algorithm.

Strengths of the Design

The strengths of the design are the ability to use multiple variables to search a database for response patterns to interventions for diverse groups identified within the data. Data-driven science enables discovery of novel and previously unknown patterns in populations and intervention approaches. This helps to generate new knowledge about patient health and the quality of the healthcare provided, which has implications in policy creation and validating or refuting evidence-based practice (Tukey, 1977; Monsen, Radosevich et al., 2012; Waltz et al., 2010).

Limitations of the Design

The limitations of the design are that no new data can be added to the data set. Also, the data were not gathered for the purpose of the study; therefore, may be incomplete or biased (Waltz et al., 2010). Using an existing database for secondary data analysis has inherent risks as the secondary researcher must understand the methods the

original researcher used to create the database and the rationale for performing the original study to determine the suitability of the database to contain information related to the researcher's question (Waltz et al., 2010).

Population and Sample

The sample includes adults ages 50 and older with one or more signs/symptoms included within the heart failure algorithm. The sample database exists within the Omaha System Data Collaborative within the University of Minnesota Center for Nursing Informatics. Data are stored in the secure data shelter of the academic health center at the University of Minnesota.

Human Subjects Considerations

This existing record-only study was submitted to the University of Missouri St. Louis Institutional Review Board (IRB) and the University of Minnesota Institutional Review Board Committee**.** Since the data within the data shelter is already Health Insurance Portability and Accountability Act (HIPAA) compliant, no identifiable data are available within the database. The University of Minnesota IRB and UMSL IRB approved the project as not constituting human subjects research according to the Department of Health and Human Services regulatory definitions.

Problem-Intervention-Outcome Meta-Model (PIO-MM)

The Problem-Intervention-Outcome Meta-Model (PIO-MM) describes an identified population sample (P) having one or more health problems for which interventions or treatments (I) are used to achieve the desired outcome (O). The outcome is a positive or negative change over time (Monsen, 2018a). This model describes what happens in healthcare and supports research and program evaluation in real-world

settings where it is not ethical or practical to conduct the gold-standard randomized controlled clinical trials. The PIO-MM model simply looks at a given population in a defined setting for which an intervention is applied and determines if the intervention is associated with improved patient outcomes.

The PIO MM specifies concepts of problem, population, intervention, outcome, time, and setting (Monsen, 2018a). This is particularly applicable to this study which is looking at adults 50 years of age and older, without restriction to race, ethnicity, genders, and marital status, in the community care setting. While this study is not longitudinally designed, the evaluation of a problem sign or symptom at the onset of the encounter, and the same problem sign or symptom evaluation applied after an intervention applied during the same encounter meets the criteria of the PIO-MM model.

Figure 4

The Prevention-Intervention-Outcome Meta-Model (PIO-MM)

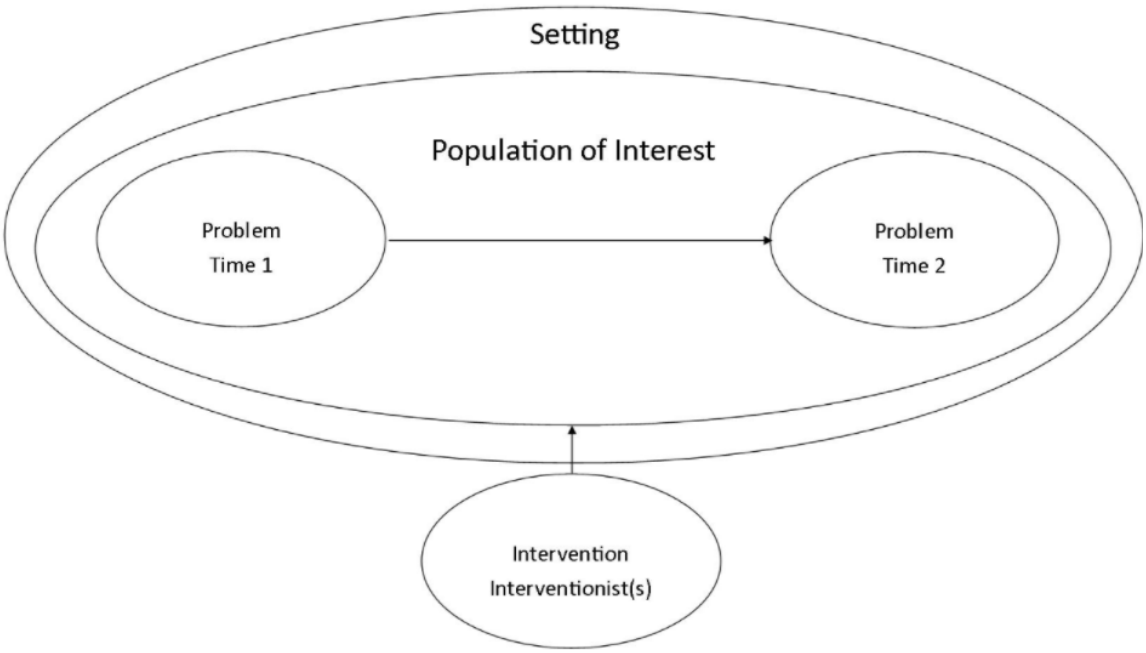


Figure 4. The Problem-Intervention-Outcome Meta-Model, Copyright Monsen, K.A. (2018a). Reprinted with permission.

This study operationalizes Monsen's PIO MM using the Omaha System terms. Applying the PIO MM to this study are as follows (adapted with permission from Monsen, 2018a).

Table 3

PIO MM concepts operationalization with Omaha System database variables

PIO MM concepts	Operationalization with Omaha System database variables
Problem	Omaha System Problem concepts
	HF Algorithm based on Omaha System Signs/symptoms
Population	Demographics (age, race/ethnicity, marital status, gender)
Intervention	Visit count
	Intervention count
Outcome	Benchmark KBS
	Change in KBS
Time	Time 2 (final) – Time 1 (baseline)
Setting	Community care setting

By using the Omaha System, designed to identify problems, interventions, and measure outcomes, the study will determine if group heterogeneity exists and if intervention-related outcomes demonstrated a positive response as determined by KBS change between admission and discharge.

Instrument

The Omaha System is a researched based classification system that documents patient care in a general to specific taxonomic method. It was developed in the 1970's by the Visiting Nurse Association of Omaha Practitioners and ancillary staff. The Omaha System is a holistic, multidisciplinary, standardized terminology, and conceptual framework. It consists of three instruments, the Problem Classification Scheme, the Intervention Scheme, and the Problem Rating Scale for Outcomes (Martin, 2005).

Problem Classification Scheme

The Problem Classification Scheme is a summarization of objective and subjective client data based on 40 diagnoses. It is considered the holistic foundation of the Omaha System comprised of terms that are mutually exclusive making it a true

taxonomy and classification scheme (Martin, 2005). It has been described as a bridge between the diagnosis and what care is provided. Out of the four levels under the Problem Classification Scheme, domains, problems, modifiers, and signs/symptoms, the levels of domains, and problem concepts of signs and symptoms are pertinent to this study.

Domains. The four domains are Environmental (4 problems), Psychosocial (8 problem concepts), Physiological (18 problem concepts), and Health-related Behaviors (8 problem concepts), for a total of 42 problem concepts.

Problem Concepts. Signs and symptoms are unique for each problem concept in the Problem Classification Scheme and are documented during the assessment if the patient demonstrates signs and symptoms of them.

Reliability and Validity. The Problem Classification Scheme was field-tested by nursing agencies in Des Moines, Delaware, and Dallas. The problems were reviewed by the testing site staff as well as the research staff demonstrating a 78% agreement in the Des Moines agencies, 73% in Delaware, and 77% congruence in the Dallas agencies (Martin & Scheet, 1992; Monsen, 2006).

Intervention Scheme.

The Intervention Scheme is a comprehensive, mutually exclusive classification of how the provider of care implemented treatments that mitigated the signs and symptoms. Interventions are problem specific to help drive a plan of care and document the care provided. The Intervention Scheme has three levels: categories, targets, and client-specific information.

Categories. There are four categories in the Omaha System Intervention Scheme. They are Teaching, Guidance, and Counseling, Treatments and Procedures, Case Management, and Surveillance designed to address the 42 Omaha System problems.

Targets. Targets are defined terms that further specify the content of the intervention.

Client-specific Information. This is not standardized and may be customized for a given program, practice, or population.

Reliability and Validity. The Intervention Scheme (IS) was tested at the Omaha VNA and Indianapolis as well as the previous testing sites of Des Moines and Delaware. The agreement of the nursing staff members, the nurse testers, and the testers themselves was measured for each intervention. The degree of agreement ranged from 42.2% to 96.9%, with eight out of twelve percentages rating agreement at 80% or above (Martin & Sheet, 1992; Monsen, 2006).

Problem Rating Scale for Outcomes

The Problem Rating Scale for Outcomes is a set of three valid, reliable measures or scales. There are three dimensions each reported on an ordinal five-point Likert scale, Knowledge, Behavior, and Status, that can be quantitatively analyzed and used to inform the practitioner whether the interventions are working/successful or not. The Problem Rating Scale for Outcomes is compatible with and complementary to other outcome indicators and terminologies that measure patient improvement progress after an intervention has been successful or not (Martin, 2005). These scores may be used to measure change over time or meeting an established benchmark (Martin, 2005). A benchmark is used to evaluate whether current practices or outcomes meet an established

standard. For the Problem Rating Scale for Outcomes, improvement is measured by increasing values on the five-point Likert scale with success measured at a value of 4 or 5 (a positive result) at the completion of the intervention (Monsen, Radosevich, et al., 2012).

Knowledge. What the patient/client knows. The purpose of this scale is to determine how well the client understands.

Behavior. What the client does. The purpose of this scale is to evaluate the client practices, performances, and skills.

Status. How the client is at the time of the assessment. The purpose of this scale is to determine if the patient/client is improving, remaining stable, or deteriorating.

With this knowledge, the practitioner is able to maximize the positive benefits of the interventions and minimize the negative aspects to assist in developing appropriate interventions. The Problem Rating Scale for Outcomes (PRSO) measures the improvement or not of the Problem Classification Scheme (PCS).

Reliability and validity. The PRSO was evaluated by the Omaha VNA and at the testing sites in Des Moines, Delaware, and Indianapolis. The percentage of KBS assignments between the VNA staff and the raters and the inter-rater agreement was evaluated for exact matches and differences. The exact match percentage ranged from 11.7% to 64.8%. Differences ranged from 82.6% to 96.1% (Martin & Sheet, 1992; Monsen, 2006).

The reliability of the PRSO scales that were assessed between a research assistant who went with the nurses into the field for 97 visits, each applying individual KBS scores during the encounter. Their KBS rating scores were found to be significantly correlated

($p < 0.01$) with knowledge ratings of 0.53, for behavior rating of 0.60, and status rating of 0.87 (Martin et al., 1999; Monsen, 2006).

The validity of the PRSO was evaluated by randomly selected panel-of experts on ten Omaha System randomly selected problems. The experts were recruited based on their credentials and expertise using the Omaha System in their practice. These experts reviewed the definition of the problem, the KBS scales, a copy of the PRSO, and guidelines for each of the problems being evaluated. Using the Content Validity Index (CVI), each item was rated on a scale of 1 (definitely no) to 4 (definitely yes). Values of 3 or 4 for an item assigned by the experts demonstrated a composite proportion for knowledge of 0.85, for behavior 0.81, and for status was 0.77. Any specific item which achieved a composite percentage of 0.80 or below was analyzed and revised before being published (Martin et al., 1999; Monsen, 2006).

The Omaha System development was multidisciplinary and funded by federal research dollars such as the Division of Nursing USDHH and the National Institute of Nursing Research. The nursing discipline has had great input into the design, maintenance and revision of this taxonomic problem solving, practice guiding and documentation system.

Computed variables

The variables that will be used in this study are a subset of the Omaha System terms (Martin, 2005), as described above. In addition, a heart failure algorithm derived from the literature based on the signs and symptoms of heart failure was computed. The signs/symptoms were: abnormal blood pressure reading, excessively rapid heart rate, excessively slow heart rate, abnormal breath patterns – dyspnea, edema, inappropriate

type/amount of exercise for age/physical condition, loss of interest/involvement in activities/self-care, somatic complaints – fatigue, sadness/hopelessness/decreased self-esteem, abnormal breath patterns – Orthopnea, abnormal breath patterns – rales, frequently wakes during the night, syncopal episodes (fainting)/dizziness, cyanosis, limited calculating/sequencing events, limited recall of recent events, diminished judgment, expresses suicidal/homicidal thoughts, and unfamiliar with options/procedures for obtaining services.

Demographic characteristics. Age range in the sample collected will be between the ages of 50 years of age and older. Race, ethnicity, genders, and marital status were included.

Data Analysis

Aim 1

Describe demographics, service characteristics, and outcomes of the sample of adults ages 50 and older with one or more signs/symptoms included in the heart failure algorithm.

Question 1.1 – What are the demographics characteristics of this sample?

Question 1.2 – Which of the 42 Omaha System problems were documented for the sample?

Question 1.3 – What were Knowledge, Behavior, and Status (KBS) scores for the sample?

1.3.1 - What is the change in Knowledge, Behavior, Status (KBS) from admission to discharge per problem?

Question 1.4 – What service characteristics (interventions and visits) were documented for the sample?

Question 1.5 – What problems/signs and symptoms were documented for the sample?

Descriptive statistics will be used to analyze the research questions in aim 1. Descriptive statistics are numeric values that summarizes the values in a sample and are used to condense and describe the characteristics of variables in a given sample or dataset to provide a clear understanding of central tendencies, distributions, and proportions within the population sample being examined (Monsen, 2018a). Central tendency consists of the median, mean, and mode of the number of the variables. The mean is the average of the values in the data, the median is the midpoint value (50^{th} percentile) of the sample, and the mode is the most frequent value found in the data. From the central tendency, the standard deviation (SD), which is an average measure of the spread of the data around the mean value if the data is normally distributed can be calculated (Monsen, 2018a).

Aim 2 - Discover groups within the sample described in Aim 1 using latent class analysis (LCA).

Question 2.1 – What are the demographics characteristics of each group?

Question 2.2 – Which of the 42 Omaha System problems were documented for each group?

Question 2.3 – What were Knowledge, Behavior, and Status (KBS) scores for each group?

2.3.1 - What is the change in Knowledge, Behavior, Status (KBS) per group from admission to discharge per problem?

Question 2.4 – What service characteristics (interventions and visits) were documented for each group?

Question 2.5 – What signs and symptoms were documented for each of the groups?

Latent Class Analysis (LCA) and descriptive statistics were used to analyze the research questions in aim 2. LCA is a measurement model in which individuals can be classified into mutually exclusive and exhaustive types, or latent classes, based on their pattern of answers on a set of categorical indicator variables (Grace-Martin, 2020). Lanza et al., 2015) describe LCA as a subset of structural equation modeling used to find group of cases in multivariate categorical data (Gao et al., 2019) and as a group of techniques used to identify unobservable, or latent, subgroups within a population or sample (Lanza et al., 2015). As the LCA reveals the number and types of different groups among the categorical data, standard descriptive statistics can be used to determine the averages and percentage of the study population with like signs and symptoms.

LCA was performed using SAS version 9.3 using PROC LCA in SAS.

Aim 3 - Compare service characteristics (interventions/visits) relative to outcomes for each of the groups identified in Aim 2.

Question 3.1 – Which intervention characteristics were associated with the best outcomes and overall, by group?

Standard comparative (inferential) statistics were used to analyze aim 3. Inferential statistics derived from the laws of probability help researchers to draw

conclusions from a given population or sample (Polit & Beck, 2014). Inferential statistics were used to test whether or not the differences or patterns discovered in the descriptive analysis and Exploratory Data Analysis (EDA) are due to chance or if a true correlation or relationship exists (Monsen, 2018a). Statistical testing performed included Chi-Square statistics and ANOVA in SAS version 9.3. ANOVA measures the differences within the groups and the differences between the groups. The chi-squared statistic sums the differences between the observed frequencies in each group (cell) and the expected frequencies if no relationship between the variables exists. (Polit & Beck, 2014).

Summary

Through the use of the PIO-MM framework identifying the population sample, identifying those who have signs/symptoms of heart failure for which an intervention has been applied, achieving a desired outcome over time demonstrating either a positive or negative change. The instrument used was the Omaha System, which, combined with demographic information, was used to answer the three study aims and related research questions. Data limitations and strengths have been described. Latent class analysis, along with ANOVA and Chi-Square, were used to perform the data analysis comparing the results with established benchmarks.

Chapter 4

Results

This chapter present the results of the data analysis that answers the questions and aims of this study. Demographics will be described for the sample and by group. Key findings will be discussed relative to the questions and aims of this study.

The Omaha System is a database of outpatient community care services provided by home care nurses and uses a framework for documenting the visits and interventions provided with outcome scores related to Knowledge, Behavior, and Status. The Omaha System represents the documentation of nursing care from the nurse's perspective, although other disciplines use the Omaha System to document their patient's Problems, Interventions, and Outcomes. However, the Omaha System is rich in nursing derived data which may provide critical information regarding the management of heart failure patients specific to the community care environment and keep them there as long as possible.

The database of the Omaha System Partnership and Data Collective at the University of Minnesota Center for Nursing Informatics was queried for the Omaha System Problems of circulation and respiration. The query of the data base for problems of Circulation and Respiration which resulted in a sample size of 4215 observations. Analysis of these individual signs and symptoms, problems, interventions, and outcome assessments results address the following aims and questions.

Aims and Questions

Aim 1 - Describe demographics, service characteristics, and outcomes of the sample of adults ages 50 and older with one or more signs/symptoms included in the heart failure algorithm.

Question 1.1 – What are the demographics characteristics of this sample? The sample demographics of age, gender, marital status race/ethnicity were evaluated. Demographics characteristics of this sample consisted of only married individuals or not married as opposed to single for a specific reason, such as being a widow, true single, or divorced. For the purposes of this study it was decided that the various non-married options (single, divorced, widowed) was not pertinent. The majority of the sample (69.3%) identified as not married. The mean age of the sample was 76.4 years of age. Patients were only included in the sample if gender was documented. The sample contained 55.9% females and 44.1% male. Minority status and race was not available in detail. The majority of the sample (62.1%) was non-Hispanic white and 30.7% of the sample “unknown”. The demographic characteristics of this sample are shown in Table 4.

Table 4

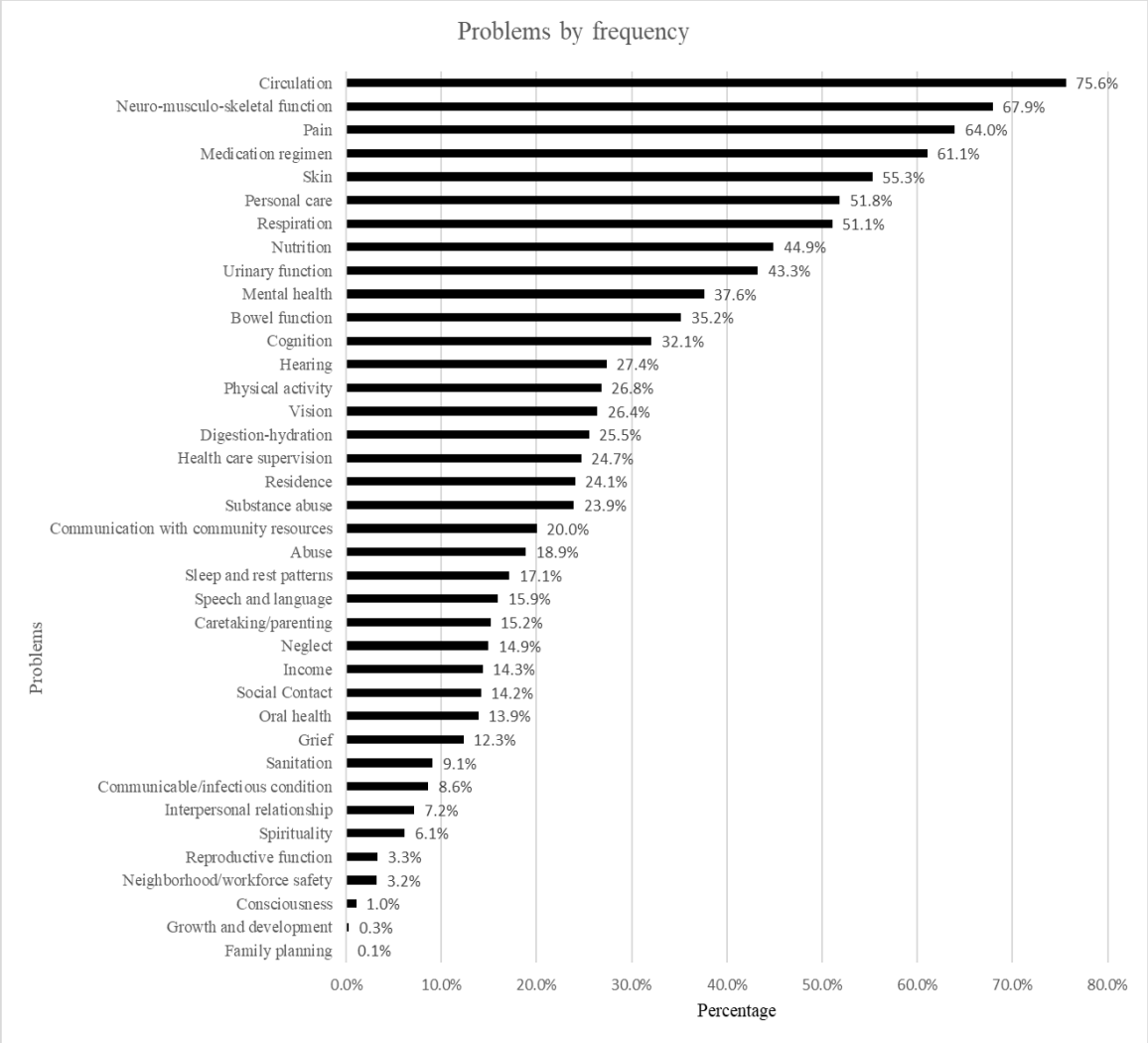
Demographics of Sample (N = 4215)

	Value	Median	SD/Percent
Mean age, SD	76.4		SD = 11.7
Age range, median	50-99	78	
Gender			
Male	1860		44.1%
Female	2355		55.9%
Marital Status			
Married	1292		30.7%
Not married	2923		69.3%
Minority status/Race			
Non-hispanic/white	2619		62.1%
Minority	303		7.2%
Unknown	1293		30.7%

Question 1.2 – Which of the 42 Omaha System problems were documented for the sample? Of the total 42 Omaha System problem classifications available, 40 were identified in the sample. The most frequent were Circulation (75.6%), Neuro-musculo-skeletal function (67.9%), Pain (64.0%), Medication regimen (61.1%), Skin (55.3%), Personal care (52.8%), Respiration (51.1%), Nutrition (44.9%), Urinary function (43.3%), Mental health (37.6%), Bowel function (35.2%), and Cognition (32.1%). Figure 5 displays the Omaha System Problems frequency by percentage.

Figure 5

Percentage of sample by problem (N = 4215)



Question 1.3 – What were Knowledge, Behavior, and Status (KBS) scores for the sample? The Knowledge, Behavior, and Status (KBS) scores are based on a 5-point Likert scale, with 1 being the lowest score and 5 being the greatest. Table 5 displays the KBS scores on admission and discharge for all the Omaha System problems with the exception of Problem 48 – Pregnancy and Problem 49 – Post Partum which was not

queried as part of this sample due to the average age of this sample of 76 years where pregnancy and post-partum would not apply.

Table 5

Change in KBS per problem from admission to discharge

Problem number	Problem description	Sample KBS scoring	Knowledge admission mean	Knowledge discharge mean	Knowledge change	Behavior admission mean	Behavior discharge mean	Behavior change	Status admission mean	Status discharge mean	Status change
PB0001	Income	604	3.37	3.40	0.03	3.88	3.89	0.01	4.11	4.12	0.01
PB0002	Sanitation	383	3.37	3.38	0.01	3.70	3.70	0.00	3.88	3.91	0.03
PB0003	Residence	1014	3.29	3.30	0.01	3.79	3.80	0.01	3.91	3.96	0.05
PB0004	Neighborhood/worforce safety	134	3.86	3.82	-0.04	4.60	4.60	0.00	4.93	4.93	0.00
PB0006	Communication with community	845	3.17	3.21	0.04	3.85	3.88	0.03	4.14	4.17	0.03
PB0007	Social Contact	597	3.41	3.43	0.02	4.06	4.07	0.01	4.37	4.39	0.02
PB0008	Role change	39	3.18	3.10	-0.08	3.41	3.46	0.05	3.31	3.38	0.07
PB0009	Interpersonal relationship	302	3.44	3.49	0.05	4.01	4.08	0.07	4.41	4.48	0.07
PB0010	Spirituality	258	3.60	3.61	0.01	4.26	4.30	0.04	4.69	4.71	0.02
PB0011	Grief	520	3.22	3.38	0.16	4.05	4.14	0.09	3.10	3.16	0.06
PB0012	Mental health	1585	3.16	3.21	0.05	3.72	3.74	0.02	3.80	3.85	0.05
PB0013	Sexuality	2	3.50	3.50	0.00	4.00	4.00	0.00	4.00	4.00	0.00
PB0014	Caretaking/parenting	640	3.50	3.30	-0.20	4.18	4.15	-0.03	4.45	4.54	0.09
PB0015	Neglect	630	3.75	3.77	0.02	4.16	4.17	0.01	4.80	4.79	-0.01
PB0016	Abuse	795	3.76	3.78	0.02	4.32	4.31	-0.01	4.91	4.91	0.00
PB0017	Growth and development	11	3.64	3.73	0.09	3.82	3.82	0.00	4.27	4.09	-0.18
PB0019	Hearing	1154	3.31	3.34	0.03	3.89	3.88	-0.01	3.88	3.90	0.02
PB0020	Vision	1113	3.33	3.35	0.02	3.93	3.92	-0.01	3.92	3.96	0.04
PB0021	Speech and language	672	3.31	3.33	0.02	4.13	4.13	0.00	4.44	4.46	0.02
PB0023	Cognition	1352	3.10	3.14	0.04	3.68	3.68	0.00	3.83	3.84	0.01
PB0024	Pain	2696	3.26	3.37	0.11	3.71	3.76	0.05	3.42	3.57	0.15
PB0025	Consciousness	44	3.36	3.41	0.05	4.36	4.36	0.00	4.23	4.20	-0.03
PB0026	Skin	2331	3.19	3.28	0.09	3.74	3.79	0.05	3.67	3.79	0.12
PB0027	Neuro-musculo-skeletal function	2863	3.14	3.28	0.14	3.58	3.66	0.08	3.20	3.40	0.20
PB0028	Respiration	2153	3.19	3.26	0.07	3.71	3.76	0.05	3.67	3.75	0.08
PB0029	Circulation	3188	3.10	3.20	0.10	3.60	3.64	0.04	3.44	3.54	0.10
PB0030	Digestion-hydration	1076	3.22	3.25	0.03	3.82	3.84	0.02	4.03	4.05	0.02
PB0031	Bowel function	1483	3.21	3.25	0.04	3.81	3.83	0.02	3.96	4.02	0.06
PB0035	Nutrition	1893	3.17	3.24	0.07	3.50	3.54	0.04	3.57	3.63	0.06
PB0036	Sleep and rest patterns	722	3.23	3.27	0.04	3.61	3.66	0.05	3.68	3.73	0.05
PB0037	Physical activity	1130	3.22	3.30	0.08	3.44	3.49	0.05	3.46	3.55	0.09
PB0038	Personal care	2185	3.37	3.13	-0.24	3.72	3.81	0.09	3.43	3.57	0.14
PB0039	Substance abuse	1009	3.33	3.34	0.01	3.52	3.54	0.02	3.81	3.84	0.03
PB0040	Family planning	5	3.60	3.20	-0.40	4.40	4.20	-0.20	4.80	4.80	0.00
PB0041	Health care supervision	1041	3.18	3.18	0.00	3.86	3.84	-0.02	4.24	4.23	-0.01
PB0042	Medication regimen	2574	3.07	3.19	0.12	3.65	3.78	0.13	3.61	3.75	0.14
PB0045	Oral health	585	3.55	3.59	0.04	4.07	4.05	-0.02	4.30	4.32	0.02
PB0046	Urinary function	1823	3.24	3.30	0.06	3.80	3.80	0.00	3.71	3.76	0.05
PB0047	Reproductive function	139	3.88	3.88	0.00	4.68	4.66	-0.02	4.89	4.93	0.04
PB0050	Communicable/infectious condition	363	3.47	3.48	0.01	4.21	4.24	0.03	4.54	4.54	0.00
	Total scores	41953									
	Average scores		3.36	3.37		3.91	3.92		4.02	4.06	
	Change from A to D			0.01			0.01			0.04	

Note: Each individual in the entire sample size of 4215 may or may not report a particular problem. Multiple problems per client may be reported which resulted in 41,953 KBS scores reported. Problems reporting less than 5% of the sample were excluded to not swew results reporting.

Question 1.3.1 - What is the change in Knowledge, Behavior, Status (KBS) from admission to discharge per problem? The change in KBS from admission to discharge per problem indicates the level of change in knowledge, behavior, and status between

admission and discharge. The time between admission and discharge was not available in this database. Table 5 demonstrates overall, 41,953 KBS scores were obtained for the 40 Omaha System Problems included in the query. The Status score on average saw the greatest amplitude of change between admission and discharge scores at 0.04. The greatest individual negative change was reported on Family Planning Knowledge (-0.40). The greatest individual positive change was reported on Neuro-musculo-skeletal function (0.20).

Question 1.4 – What service characteristics (interventions and visits) were documented for the sample? The entire sample consisted of 4215 patients. Table 6 reports the visits and interventions recorded for 4208 patients from 2013 to 2018. The mean number of visits per person was 49, and the mean number of interventions per person in the sample was 622. The number of visits and interventions were per patient, which could have had only one episode of care or several. No set number of visits or interventions per episode of care was available to determine the length of care between admission and discharge.

Table 6

Number of sample visits and interventions (N = 4208)

	M	SD	Mdn	Min	Max
Visits	48.8	28.2	46.0	1.0	254.0
Interventions	622.0	1199.1	200.0	1.0	19373.0

Question 1.5 – What problems/signs and symptoms were documented for the sample? The database was first queried for the signs and symptoms related to heart failure as discovered in the literature. The six most common signs and symptoms of heart failure reported in the literature were rapid heart rate, slow heart rate, abnormal blood

pressure, actual patient weight (+/- 4 lbs.), abnormal breath sounds – dyspnea, and edema. These signs and symptoms fall into the Omaha System Problem schema of Respiration and Circulation. For the database query, inclusion of these problems allowed for data related to the signs and symptoms of heart failure to be extracted. Table 7 displays the sample signs and symptoms associated with the respective Omaha System Problems. The most reported signs and symptoms of the sample were decreased muscle strength with 2600 (61.68%), expresses discomfort/pain with 2559 (60.71%), and edema with 2383 (56.54%). There was a significant gap (1053 occurrences, 24.99%) between the top three reported signs and symptoms and the next reported sign and symptom urinary incontinence with 1330 (31.55%), followed by abnormal blood pressure 1138 (28.09%) followed by lesion/pressure ulcer 1141 (27.07%), and abnormal breath patterns/dyspnea 1138 (27.0%). This indicates reported urinary, cardiovascular, respiratory, and skin problems were considerable. Abnormal frequency/consistency of stool was reported 962 (22.82%) times. The rest of the signs and symptoms were reported with less than 20% of the total responses.

Table 7

Frequency of signs and symptoms (N = 4215)

Problem	Description	Signs/ symptoms	Description	Number in sample	Percent of sample reporting
PB0027	Neuro-musculo-skeletal function	SS2702	decreased muscle strength	2600	61.68
PB0024	Pain	SS2401	expresses discomfort/pain	2559	60.71
PB0029	Circulation	SS2901	edema	2383	56.54
PB0046	Urinary function	SS4602	incontinent of urine	1330	31.55
PB0029	Circulation	SS2908	abnormal blood pressure reading	1184	28.09
PB0026	Skin	SS2601	lesion/pressure ulcer	1141	27.07
PB0028	Respiration	SS2809	abnormal breath patterns/dyspnea	1138	27.00
PB0028	Respiration	SS2801	abnormal breath patterns	997	23.65
PB0031	Bowel function	SS3101	abnormal frequency/consistency of stool	962	22.82
PB0023	Cognition	SS2303	limited recall of recent events	821	19.48
PB0012	Mental health	SS1201	sadness/hopelessness/decreased self-	704	16.70
PB0023	Cognition	SS2301	diminished judgment	675	16.01
PB0019	Hearing	SS1901	difficulty hearing normal speech tones	625	14.83
PB0029	Circulation	SS2907	syncopal episodes (fainting)/dizziness	500	11.86
PB0023	Cognition	SS2305	limited calculating/sequencing skills	410	9.73
PB0020	Vision	SS2001	difficulty seeing small print/calibrations	406	9.63
PB0012	Mental health	SS1203	loss of interest/involvement in activities/self-care	369	8.75
PB0036	Sleep and rest patterns	SS3602	frequently wakes during night	364	8.64
PB0030	Digestion-hydration	SS3005	anorexia	326	7.73
PB0037	Physical activity	SS3703	inappropriate type/amount of exercise for age/physical condition	277	6.57
PB0029	Circulation	SS2911	excessively rapid heart rate	211	5.01
PB0045	Oral health	SS4501	missing/broken/malformed teeth	168	3.99
PB0012	Mental health	SS1214	somatic complatins/fatigue	156	3.70
PB0006	Communication with community resources	SS0601	unfamiliar with options/procedures for obtaining services	147	3.49
PB0029	Circulation	SS2912	excessively slow heart rate	98	2.33
PB0021	Speech and language	SS2105	limited enunciation/clarity	85	2.02
PB0050	Communicable/Infectious condition	SS5001	infection	61	1.45
PB0028	Respiration	SS2805	cyanosis	36	0.85
PB0012	Mental health	SS1218	expresses suicidal/homicidal thoughts	21	0.50
PB0025	Consciousness	SS2501	lethargic	12	0.28
			Total signs and symptoms	20766	

Aim 2 - Discover groups within the sample described in Aim 1 using latent class analysis (LCA).

The review of the literature revealed that signs and symptoms related to Omaha System Problems Respiration and Circulation, specifically, abnormal breathing patterns

such as dyspnea or cyanosis, syncopal episodes (fainting)/dizziness, abnormal blood pressure reading, excessively rapid or slow heart rate, and edema were considered indicative signs and symptoms of heart failure. The primary query including theses signs and symptoms of heart failure of the entire sample of signs and symptoms found in Table 4.4 reported three overwhelming signs and symptoms within the entire sample of 30 reported signs and symptoms. They were decreased muscle strength (n = 2600), expresses discomfort/pain (n = 2559), and edema (n = 2382). Because these three major signs and symptoms were prevalent in the entire sample, the LCA could not discriminate other groups. By excluding them from further LCA, this allowed other signs and symptom groupings to be discovered.

To determine how well the variables predicted the meaningful group membership, a model fit test was performed. There are three model analyses which provide the model fit. These analyses are LL, which is the log likelihood, p-value, which is the statistical significance, and the BIC or Bayes Information Criterion, a statistic that aids in model selection whereby a penalty component helps to avoid model overfitting. An adjusted BIC with a high log-likelihood using fewer variables results in a lower value representing a better fit. Desired entropy to determine K class membership into groups, or the number of latent classes for this model, is between 0.77 and 0.80. Based on the log-likelihood of -33435.4, an adjusted BIC of 14561.4, and an entropy of 0.77 for the 4 group model, which did not differ much from the log-likelihood of -33389.8, adjusted BIC of 14415.0, and entropy of 0.77 for the 5 group model, it was decided based on applicable nursing theory and the information criteria provided related to heart failure that the 4 group model

was the best model fit and was used for this LCA model. Models with 2 or 3 groups did not meet entropy criteria and were eliminated as seen in table 8.

Table 8

LCA model fit statistics

Statistical test	2 groups	3 groups	4 groups	5 groups
Log-likelihood	-34159.7	-33692.47	-33535.43	-33389.8
G-squared	15236.3	14301.8	13987.7	13696.5
AIC	15346.3	14301.76	14209.7	13974.5
BIC	15695.3	14994.5	14914.1	14856.7
cAIC	15750.3	15077.5	15025.1	14995.7
Adjusted BIC	15520.6	14730.77	14561.4	14414.97
Entropy	0.68	0.76	0.77*	0.77*

* value meets entropy criteria of 0.77 to 0.80 for model fit

Table 9 is the LCA on the remaining 27 signs and symptoms after the three prevalent signs and symptoms, decreased muscle strength, expresses discomfort/pain and edema were removed. The LCA data were analyzed demonstrating by frequency three major groupings of signs and symptoms related to Omaha System Problems. One group had a greater frequency of signs and symptoms of heart failure than the rest of the groups and was designated as Group 1 - Heart failure. The second group had signs and symptoms related to the Mental health Problem and was designated as Group 2 – Mental health. The third group had greater signs and symptoms related to Cognition and was labeled as Group 3 - Cognition. The fourth group had no particular grouping of increased signs and symptoms and was named Group 4 - General/Other. Of note, are many of the signs and symptoms associated with a population that requires community care services including incontinence of urine and abnormal frequency/consistency of stool. In addition, the heart failure group had increased frequencies of mental health, cognitive, sensory

(hearing and vision), and digestive signs and symptoms. The General/Other group had increased signs and symptoms of lesions/pressure ulcers, which may have been the primary reason for why community care may have been necessary. All groups had signs and symptoms of heart failure established by the primary query. The sign and symptom results in Table 9 with the grey highlighted fields were respective to the group name in the header of Heart failure, Mental health, Cognition, and General/other groups. For the remainder of this data analysis the groups will be referred to by their respective group name.

Table 9

Groups discovered within the sample by LCA by percentage of signs and symptoms present

Signs and Symptoms	Group 1 - Heart failure	Group 2 - Mental health	Group 3 - Cognition	Group 4 - General/ other
abnormal breath patterns/dyspnea/orthopnea	43.42%	22.90%	24.90%	19.04%
abnormal breath sounds/rales	42.78%	27.49%	33.03%	22.74%
syncopal episodes (fainting)/dizziness	22.68%	19.78%	13.57%	8.10%
abnormal blood pressure reading	53.74%	27.76%	28.69%	22.24%
excessively rapid heart beat	13.25%	4.22%	5.13%	3.22%
excessively slow heart beat	6.67%	3.82%	1.57%	1.33%
cyanosis	2.27%	1.16%	0.04%	0.68%
unfamiliar with options/procedures for obtaining services	12.86%	7.01%	3.25%	1.01%
sadness/hopelessness/decreased self-esteem	48.12%	64.28%	12.91%	4.71%
loss of interest/involvement in activities/self care	26.72%	50.46%	7.22%	0.00%
somatic complaints/fatigue	12.86%	16.95%	3.87%	0.00%
expresses suicidal/homicidal thoughts	1.49%	1.96%	0.86%	0.02%
difficulty hearing normal speech tones	49.88%	6.88%	6.64%	9.70%
difficulty seeing small print/calibrations	35.10%	3.60%	4.78%	5.70%
limited enunciation/clarity	6.60%	0.00%	1.37%	1.37%
diminished judgement	26.93%	5.83%	72.24%	2.58%
limited recall of recent events	51.54%	3.08%	62.02%	5.03%
limited calculating /sequencing skills	13.19%	0.12%	52.49%	0.83%
lethargic	1.04%	0.48%	0.24%	0.10%
lesion/pressure ulcer	31.46%	29.17%	26.50%	26.14%
anorexia	6.93%	7.81%	22.47%	4.70%
abnormal frequency/consistency of stool	54.87%	25.53%	25.47%	14.74%
frequently wakes during the night	38.57%	11.12%	1.23%	3.22%
inappropriate type/amount of exercise for age/physical condition	14.97%	9.49%	2.38%	5.24%
missing/broken/malformed teeth	14.50%	0.80%	3.85%	2.04%
incontinent of urine	56.46%	34.10%	43.40%	23.08%
infection	2.22%	0.46%	1.53%	1.37%

Note: Grey highlighted areas indicate signs and symptom prevalence in a particular Omaha System Problem.

Question 2.1 – What are the demographics characteristics of each group?

Table 10 The mean age varies across groups from 72.1 in the mental health group to 79.1 in the cognition group. Gender was not statistically significant between groups. Minority status was significant ($p < 0.001$) with non-minority having a greater percentage of the population in all groups. Factoring in the significant percentage of reported "unknown" minority status in each group this could mitigate that significance. The

percentage of married individuals in each group was mental health – 31.4%, general/other – 30.9%, cognition – 30.52%, heart failure – 28.85%. There was no statistical significance between the groups for marital status.

Table 10

Demographics by group (N = 4215

	Heart Failure	Mental Health	Cognition	General/ Other	p value
Mean age in years	74.2	72.1	79.1	76.7	
Gender					
Male	41.8%	38.8%	44.6%	45.0%	0.157
Female	58.2%	61.2%	55.4%	55.0%	
Marital status					
Married	28.85%	31.40%	30.52%	30.97%	0.78
Not married	71.15%	68.60%	69.48%	69.03%	
Minority Status					0.001
Non-Hispanic/white	49.6%	59.3%	77.7%	62.0%	
Minority	15.6%	13.2%	3.4%	5.7%	
Unknown	34.9%	27.5%	18.9%	32.3%	

Question 2.2 – Which of the 42 Omaha System problems were documented for each group? Table 11 demonstrates the percentage of Omaha System Problems by group.

Table 11

Percentage of Omaha System Problems by group (N = 4215)

Problem number	Problem description	Heart Failure (n = 565)	Mental Heath (n = 258)	Cognition (n = 534)	General/ Other (n = 2858)	Entire sample (N = 4215)
PB0001	Income	29%	15%	8%	13%	14%
PB0002	Sanitation	23%	11%	3%	7%	9%
PB0003	Residence	42%	26%	15%	22%	24%
PB0004	Neighborhood/workplace safety	1%	2%	3%	4%	3%
PB0006	Communication with community resources	34%	27%	12%	18%	20%
PB0007	Social contact	20%	10%	9%	14%	14%
PB0008	Role change	2%	2%	0%	1%	1%
PB0009	Interpersonal relationship	13%	6%	4%	7%	7%
PB0010	Spirituality	10%	3%	2%	6%	6%
PB0011	Grief	3%	8%	40%	9%	12%
PB0012	Mental health	70%	88%	25%	29%	38%
PB0014	Caretaking/parenting	20%	13%	10%	15%	15%
PB0015	Neglect	14%	24%	5%	16%	15%
PB0016	Abuse	14%	26%	8%	21%	19%
PB0019	Hearing	61%	19%	14%	24%	27%
PB0020	Vision	56%	24%	14%	23%	26%
PB0021	Speech and language	21%	12%	10%	16%	16%
PB0023	Cognition	65%	21%	47%	24%	32%
PB0024	Pain	82%	72%	40%	64%	64%
PB0025	Consciousness	2%	1%	0%	1%	1%
PB0026	Skin	71%	62%	29%	57%	55%
PB0027	Neuro-musculo-skeletal function	86%	66%	42%	69%	68%
PB0028	Respiration	73%	62%	28%	50%	51%
PB0029	Circulation	87%	78%	45%	79%	76%
PB0030	Digestion-hydration	50%	27%	17%	22%	26%
PB0031	Bowel function	66%	36%	23%	31%	35%
PB0035	Nutrition	68%	48%	30%	43%	45%
PB0036	Sleep and rest patterns	54%	17%	6%	12%	17%
PB0037	Physical activity	52%	28%	13%	24%	27%
PB0038	Personal care	68%	52%	33%	52%	52%
PB0039	Substance abuse	38%	30%	13%	23%	24%
PB0041	Health care supervision	36%	33%	14%	24%	25%
PB0042	Medication regimen	81%	69%	47%	59%	61%
PB0045	Oral health	26%	9%	8%	13%	14%
PB0046	Urinary function	75%	43%	30%	40%	43%
PB0047	Reproductive function	1%	1%	3%	4%	3%
PB0050	Communicable/infectious condition	12%	4%	4%	9%	9%

Note. Due to mean age of the population sample of 76.4 years, Problems 48 - Pregnancy and 49 - Postpartum were ommitted from the query. Similarily, Problem 13 - Sexuality, Problem 17 - Growth and Development, and Problem 40 - Family planning, were queried returning zero results.

In the Heart Failure group - 87% of the individuals had documented signs and symptoms associated with Omaha System Problem of Circulation followed closely by

Neuro-musculo-skeletal function (86%), Pain (82%), and Medication regimen (81%). Problems reported in this group greater than 50% in order of percentage were Urinary function (75%), Respiration (73%), Skin (71%), Mental health (70%), Nutrition (68%), Personal care (68%), Bowel function (66%), Cognition, (65%), Hearing (61%), Vision (56%), Sleep and rest patterns (54%), Physical activity (52%), and Digestion-hydration (50%). The Heart Failure group had 17 Omaha System Problems with 50% or greater of the individuals having more of the signs and symptoms present, twice that of any other group (Mental health reported 8 problems by greater than 50% of the individuals) indicating that these individuals had multiple and significant numbers of problems.

In the Mental Health group, 88% had documented signs and symptoms associated with Omaha System Mental Health, followed by Circulation (78%). Problems reported greater than 50% include Pain (72%), Medication Regimen (69%), Neuro-musculo-skeletal function (66%), Skin (62%), Respiration (62%), and Personal care (52%).

In the Cognition group – 47% of the individuals had documented signs and symptoms associated with Omaha System Problem 23 – Cognition tied with Medication regimen (47%). These problems were followed closely by Circulation (45%) and Neuro-musculo-skeletal function (42%). None of the percentages exceeded 50% of the individuals reporting signs and symptoms in this group.

In the General/Other group -79% of the individuals had documented signs and symptoms associated with Omaha System Circulation which contains the symptom of edema. Percentages greater than 50% were also reported for Omaha System Neuro-musculo-skeletal function (69%), and Pain (64%) consistent with the analysis of the

entire sample. Other problems with greater than 50% reporting were Medication regimen (59%), Skin (57%), Personal care (52%), and Respiration (50%).

Question 2.3 – What were Knowledge, Behavior, and Status (KBS) scores for each group? The KBS scores for each group are found in Table 12. The mean column is the mean admission and discharge score for each group. The mean change is the difference between the admission and discharge means. The standard deviation column is the variability of the scores from the mean. The minimum scores indicate that at least 1 person reporting a change in the KBS score either positively or negatively for that value. Thus a -1.25 in the Heart failure, line for Knowledge mean change, indicates that at least one person in the sample had a decrease in the Knowledge concept of 1.25 from admission to discharge evaluation. The maximum column indicates the highest values obtained within the group for the KBS concept from admission to discharge. The highest value that can be reported is a 5 indicating complete grasp of the particular KBS concept as seen in the Heart failure group Knowledge at admission and discharge.

Table 12

Knowledge, Behavior, Status scores for each group

Group	KBS Variable	Mean	Std Dev	Minimum	Maximum
Heart Failure	Knowledge admission	3.11	0.56	1.00	5.00
(n = 565)	Knowledge discharge	3.18	0.58	1.00	5.00
	Knowledge mean change	0.07	0.32	-1.25	2.00
	Behavior admission	3.43	0.55	1.00	5.00
	Behavior discharge	3.47	0.57	1.00	5.00
	Behavior mean change	0.05	0.38	-1.13	3.00
	Status admission	3.34	0.55	1.00	4.94
	Status discharge	3.40	0.54	1.00	4.94
	Status mean change	0.05	0.29	-0.88	2.00
Mental Health	Knowledge admission	3.15	0.58	1.33	5.00
(n = 258)	Knowledge discharge	3.19	0.57	1.33	5.00
	Knowledge mean change	0.05	0.32	-1.00	1.43
	Behavior admission	3.56	0.61	1.00	5.00
	Behavior discharge	3.61	0.60	1.00	5.00
	Behavior mean change	0.05	0.31	-1.41	2.00
	Status admission	3.50	0.64	1.00	5.00
	Status discharge	3.55	0.63	1.00	5.00
	Status mean change	0.05	0.34	-1.25	2.00
Cognition	Knowledge admission	2.95	0.62	1.00	4.36
(n = 534)	Knowledge discharge	3.12	0.66	1.00	4.64
	Knowledge mean change	0.17	0.47	-2.00	2.00
	Behavior admission	3.52	0.80	1.00	5.00
	Behavior discharge	3.69	0.74	1.00	5.00
	Behavior mean change	0.17	0.57	-2.00	4.00
	Status admission	3.16	0.62	1.00	4.89
	Status discharge	3.35	0.62	1.00	5.00
	Status mean change	0.19	0.51	-1.25	3.00
General/Other	Knowledge admission	3.25	0.57	1.00	5.00
(n = 2858)	Knowledge discharge	3.36	0.59	1.00	5.00
	Knowledge mean change	0.11	0.33	-1.76	2.00
	Behavior admission	3.75	0.61	1.00	5.00
	Behavior discharge	3.84	0.62	1.00	5.00
	Behavior mean change	0.09	0.34	-1.33	3.00
	Status admission	3.58	0.67	1.00	5.00
	Status discharge	3.72	0.68	1.00	5.00
	Status mean change	0.13	0.38	-2.00	3.00

Question 2.3.1 What is the change in Knowledge, Behavior, Status (KBS) per group from admission to discharge per problem? Table 13 reports the mean change by group. Change in KBS was largest for the Cognition group with a Knowledge mean change of 0.17, a Behavior mean change of 0.17 and a Status mean change of 0.19. The group with the least change was the Mental health group with a Knowledge mean change of 0.05, a Behavior mean change of 0.05, and a Status mean change of 0.05. The Mental health group was closely followed by the Heart failure group with a Knowledge mean change of 0.07, a Behavior mean change of 0.05 and a Status mean change of 0.05. The General/Other group showed a Knowledge mean change of 0.11, a Behavior mean change of 0.09 and a Status mean change of 0.13.

Table 13

Percent change in Knowledge, Behavior, and Status (KBS) per group from admission to discharge (N = 4208)

Concept	Knowledge			Behavior			Status		
	A	D	chg	A	D	chg	A	D	chg
Heart failure (n = 562)	3.11	3.18	0.07	3.43	3.47	0.05	3.34	3.40	0.05
Mental health (n =258)	3.15	3.19	0.05	3.56	3.61	0.05	3.50	3.55	0.05
Cognition (n = 534)	2.95	3.12	0.17[a]	3.52	3.69	0.17[a]	3.16	3.35	0.19[a]
General/Other (n = 2854)	3.25	3.36	0.11	3.75	3.84	0.09	3.58	3.72	0.13

Note. A = Admission score, D = Discharge score, chg = Change between admission and discharge scores
[a] Indicates highest value per KBS concept

Question 2.4 – What service characteristics (interventions and visits) were documented for each group? The visit service characteristics by group shown in Table 14 demonstrate that the Heart failure group had the greatest average number of visits (M = 58.6) and interventions (M = 1353.1). The Mental health group was second highest in visits (M = 54.3) and interventions (M = 772.1). The Cognition group was third highest

for visits (M = 51.7) and interventions (M = 723.3). The General/Other group had the least average number of visits (M = 45.8) and interventions (M = 445.5).

Table 14

Visits and interventions by group (N =4215)

	Visits			Interventions		
	Mean	SD	Median	Mean	SD	Median
Heart Failure (n = 565)	58.6	25.2	55.0	1353.1	1733.0	761.5
Mental Health (n = 258)	54.3	28.4	51.5	772.1	1290.0	295.0
Cognition (n = 534)	51.7	26.7	49.0	723.3	1549.8	231.0
General/Other (n = 2858)	45.8	28.5	42.0	445.5	889.1	162.0

Tukey-Kramer adjustment was used to check for normally distributed means variability. Alpha was set at 0.05, F = 39.98. Results for visits were $p < 0.001$ for the General/Other group compared to all the rest of the groups; Mental health, Cognition, and Heart failure. Mental health group was not statistically significant with the Cognition group ($p < 0.63$) or the Heart failure group ($p < 0.16$). Cognition was statistically significant with the Heart failure group ($p < 0.001$).

Tukey-Kramer adjustment results for interventions for the model with alpha set at 0.05 and F = 99.41, were Heart failure was statistically significant for all groups; Mental health, General/Other, and Cognition ($p < 0.001$). The Mental health group was not statistically significant with the Cognition group ($p < 0.95$) but statistically significant for the Heart failure and General/Other group ($p < 0.001$). These results demonstrate that the group means for visits and interventions are not equal with differences between the groups.

The results demonstrated that all of the comparisons for both interventions and visits are highly significant to the Heart failure group. The Heart failure group has considerably more visits and interventions with standard parametric testing with Anova with post hoc testing.

Non-parametric testing with Kruskal-Wallis and Wilcoxon Rank Sums testing for non-parametric distribution of the data adjusted for multiple comparisons test for visits and interventions were both statistically significant ($p < 0.001$) for the Heart failure group.

Question 2.5 – What signs and symptoms and problems were documented for each of the groups?

Table 15 lists the signs and symptoms identified by Problem and group.

Table 15

Sample signs and symptoms by problem and group (N = 4215)

Problem description	Signs and Symptoms	Heart failure	Mental health	Cognition	General /	Sample total
Communication with community resources	unfamiliar with options/procedures for obtaining services	83	20	15	29	147
Mental health	sadness/hopelessness/decreased self-esteem	295	184	71	154	704
Mental health	loss of interest/involvement in activities/self-	160	170	39	0	369
Mental health	somatic complaints/fatigue	79	56	21	0	156
Mental health	expresses suicidal/homicidal thoughts	8	6	6	1	21
Hearing	difficulty hearing normal speech tones	300	12	26	287	625
Vision	difficulty seeing small print/calibrations	214	7	18	167	406
Speech and language	limited enunciation/clarity	40	0	6	39	85
Cognition	diminished judgment	157	13	428	77	675
Cognition	limited recall of recent events	314	2	342	163	821
Cognition	limited calculating/sequencing skills	77	0	315	18	410
Consciousness	lethargic	7	1	1	3	12
Skin	lesion/pressure ulcer	180	78	138	745	1141
Respiration	abnormal breath patterns	258	58	136	545	997
Respiration	abnormal breath patterns/dyspnea	247	74	166	651	1138
Respiration	cyanosis	12	2	0	22	36
Circulation	syncopal episodes (fainting)/dizziness	133	64	74	229	500
Circulation	abnormal blood pressure reading	322	71	149	642	1184
Circulation	excessively rapid heart rate	80	11	25	95	211
Circulation	excessively slow heart rate	42	12	8	36	98
Digestion-hydration	anorexia	36	23	136	131	326
Bowel function	abnormal frequency/consistency of stool	330	66	140	426	962
Sleep and rest patterns	frequently wakes during night	238	30	6	90	364
Physical activity	inappropriate type/amount of exercise for age/physical condition	89	28	13	147	277
Oral health	missing/broken/malformed teeth	87	0	24	57	168
Urinary function	incontinent of urine	334	91	236	669	1330
Communicable/Infectious condition	infection	10	1	9	41	61
	Total sgins and symptoms	4132	1080	2548	5464	13224

The Heart Failure group documented significant numbers of heart failure signs and symptoms such as abnormal blood pressure (n = 322), abnormal breath patterns (n = 258), abnormal breath patterns – dyspnea (n = 247). In addition, this group also

documented significant numbers of other physiological signs and symptoms around Problem 31 – Bowel function – abnormal frequency/consistency of stool (n = 330), Problem 36 – Sleep and rest patterns – frequently wakes during night (n = 238), Problem 46 – Urinary function – incontinent of urine (n = 334), and Problem 26 – Skin – lesion/pressure ulcer (n = 180). Other signs and symptoms of note are Problem 19 – Hearing – difficulty heart normal speech tones (n = 300) and Problem 20 – Vision – difficulty seeing small print/calibrations (n = 214). The heart failure group's multiple increased signs and symptoms indicate that this group of patients is more seriously ill than the rest of the sample.

The Mental Health group had higher numbers of Problem 12 – Mental health signs and symptoms such as sadness/hopelessness/decreased self-esteem (n = 184), loss of interest/involvement in activities/self-care (n = 170), somatic complaints/fatigue (n = 56). The heart failure and mental health groups both had significant signs and symptoms of Problem 12 - Mental health; however, expresses suicidal/homicidal thoughts numbers were small for the heart failure (n = 8) and the mental health (n = 6) groups.

The Cognition group had significant number of signs and symptoms from Problem 23 – Cognition. These signs and symptoms were diminished judgement (n = 428), limited recall of recent events (n = 342), and limited calculating/sequencing skills (n = 315). This group was similar to the general/other group with signs and symptoms associated with Problem 26 – Skin – lesion/pressure ulcer (n = 138), Problem 30 – Digestion – hydration – anorexia (n = 136), Problem 31 – Bowel function – abnormal frequency/consistency of stool (n = 140), and Problem 46 – Urinary function – incontinent of urine (n = 334).

The General/Other group had not only significant numbers of the heart failure signs and symptoms, such as Problem 29 – Circulation – abnormal blood pressure reading (n = 1184), but generalized physiological signs and symptoms such as Problem 26 – Skin – lesion/pressure ulcer (n = 745), Problem 31 – Bowel function – abnormal frequency/consistency of stool (n = 426), Problem 40 – Digestion – hydration – anorexia (n = 131), and Problem 46 – Urinary function – incontinent of urine (n = 669).

Aim 3 – Compare service characteristics (interventions/visits) and outcomes for each of the groups identified in Aim 2.

The visits and interventions by group are found in table 16. Unadjusted intervention numbers for the entire group appeared skewed by outliers of upwards of 18,000 interventions for at least one person in the cognition group. Individuals with more than 5,000 interventions were removed from the analysis to address this. The General/Other group had the greatest portion of the sample (n = 2854) yet had the fewest average visits (M = 45.9) and interventions (M = 445.5). The Heart Failure group (n = 562) had the greatest average number of visits (M = 58.6) and interventions (M = 1353.1), indicating they had the sickest clients needing visits and interventions. The SD was extensive (1733.0) in the heart failure group, indicating either great variability or some very extreme outliers. The median of 761.5 is a more realistic number and would indicate that the heart failure group was maintained in the community care environment for a longer period of time, perhaps several years. The Mental Health group (n = 258) ranked second for visits (M = 54.4) and for interventions (n = 772.1). The Cognition group (n = 534) ranked third for visits (n = 51.7) and interventions (n = 1353.1).

Table 16

Visits and interventions by group (N = 4208)

		M	SD	Mdn
Heart failure (n = 562)	Visits	58.6[a]	25.2	55.0
	Interventions	1353.1[a]	1733.0	761.5
Mental health (n = 258)	Visits	54.4	28.4	51.5
	Interventions	772.1	1290.0	295.0
Cognition (n = 534)	Visits	51.7	26.7	49.0
	Interventions	723.3	1549.8	231.0
General/other (n = 2854)	Visits	45.9	28.5	42.0
	Interventions	445.5	889.1	162.0

a = higest values

In order to determine if a correlation exists between the number of interventions and discharge status (final outcome), Spearman's correlation and Pearson's correlation were utilized to make this determination. Pearson's correlation would measure the strength and direction of a linear relationship between two variables. Spearman's correlation measures the strength and direction between two ranked (ordinal) variables. The correlation coefficient measures the degree of the relationship between two rankings and can be used to assess the significance of the relation between them. Table 17 indicates interventions and outcomes by group under both Pearson (parametric) and Spearman (non-parametric) correlations.

Table 17

Interventions and outcomes by group

Groups		Pearson Correlation		Spearman Correlation	
	Interventions	SD mean	p	SD mean	p
Heart Failure	536	-0.002	0.959	0.023	0.598
Mental Health	251	0.225	< 0.001*	0.212	< 0.001*
Cognition	523	0.210	< 0.001*	0.168	< 0.001*
General/Other	2837	0.05	< 0.001*	0.066	< 0.001*
Entire Sample	4147	0.020	0.196	0.213	0.170

* $p < 0.001$

The Mental Health, the General/Other, and the Cognition groups have a highly statistically significant ($p = < 0.001$) positive correlation of interventions with discharge status under Spearman's correlation. However, the Heart Failure group did not have a statistically significant ($p = 0.959$) correlation of interventions to discharge status. The direction of the change was slightly negatively correlated between the number of interventions to discharge status outcomes which shows that despite having greater number of visits, the discharge status outcomes of the clients in the heart failure group did not improve.

Table 18 represents the change in interventions and outcomes by group. Parametric testing of the Cognition group does show a positive correlation between final discharge status ($p < 0.001$) and the number of interventions the client received. The Mental Health group did not demonstrate statistical significance ($p = 0.809$) between final discharge status and the number of interventions provided. The General/Other group was statistically significant ($p <0.001$) but negatively correlated, indicating that despite increased interventions, the client's final discharge status outcome declined. The Heart Failure group was not statistically significant ($p = .662$), demonstrating that there was no

correlation between the number of interventions and final discharge status outcome. The direction of the analysis was a negative correlation, but not significant in this analysis.

Non-parametric testing for the Mental health (p = 0.398), General/Other (p = 0.816), and Heart Failure groups (p = 0.412) were all statistically insignificant. The cognition group was statistically significant (p = 0.026), indicating that the intensity of interventions and final discharge status were correlated. The statistical analysis does not support a correlation between intensity of interventions and final discharge status for the Mental Health group, the General/Other, or the Heart Failure group. However, the Cognition group had a positive correlation between interventions and intensity to discharge status outcomes.

Table 18

Change in interventions and outcomes by group

Groups		Pearson Correlation		Spearman Correlation	
	Interventions	Change SD mean	p	Change SD mean	p
Heart Failure	536	-0.019	0.662	-0.035	0.412
Mental Health	251	-0.015	0.809	0.053	0.398
Cognition	523	0.162	< 0.001*	0.097	0.026
General/Other	2837	-0.065	< 0.001*	0.004	0.816
Entire Sample	4147	-0.031	0.043	-0.011	0.479

* $p < 0.001$

Question 3.1 – Which intervention characteristics were associated with the best outcomes and overall by group? The outcomes by group are graphically depicted in Figure 6 demonstrating that in the Heart Failure group, the correlation between interventions and discharge status outcomes remained unchanged. Final status and change in status from admission to discharge remained basically unchanged. In the

Mental Health group, interventions increased, final discharge status scores increased, but no change in overall status was observed. The Cognition group was the only group to have a positive correlation between increased interventions and increased final discharge status as well as a positive change in status. The General/Other group interventions remained the same, final discharge status scores remained the same, and change in status remained the same indicating that the intensity of the interventions did not change discharge status or overall status.

Figure 6

Number of interventions, final discharge status, and status change

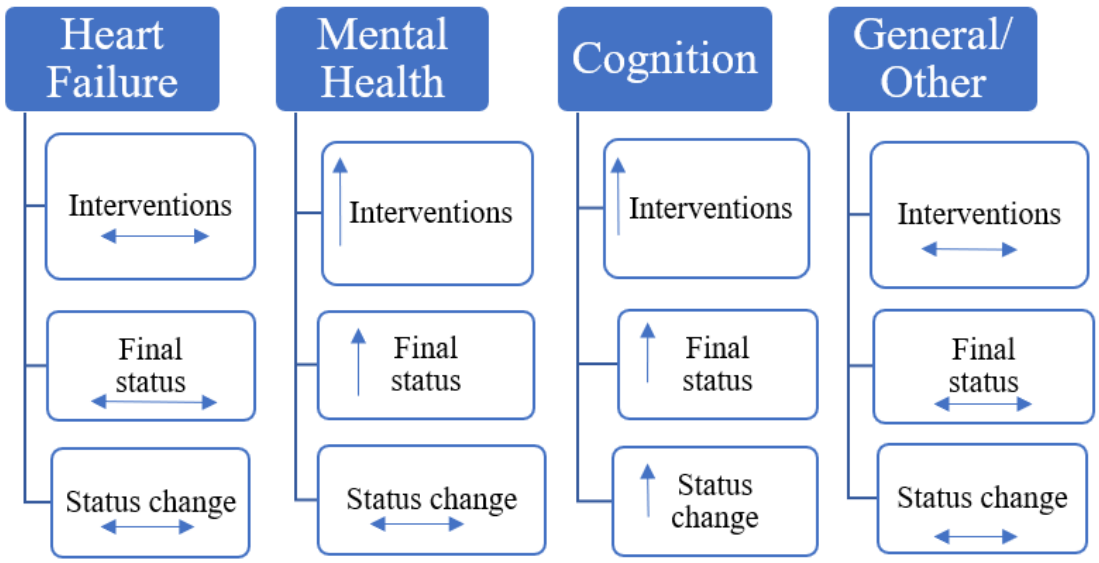
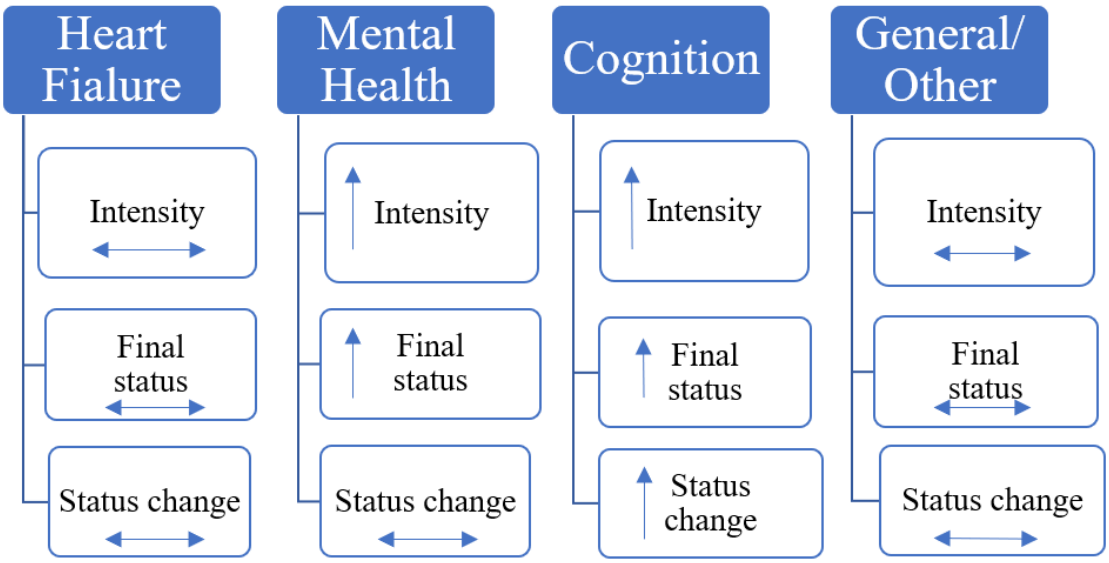


Figure 7 depicts the relationship found in the intensity of the interventions final discharge status and status change. In the Heart Failure group as intensity of interventions per visit remains the same, final discharge status and change in status both remain the same. In the Mental health group, as intensity of interventions and visits increases, final discharge status increases, but change in status remains the same. In the Cognition group as intensity of interventions per visit increases, final discharge status and change in status

both increase. In the General/Other group as intensity of interventions per visit remains flat, final discharge status and change in status remain also unchanged.

Figure 7

Intensity, final discharge status, and status change

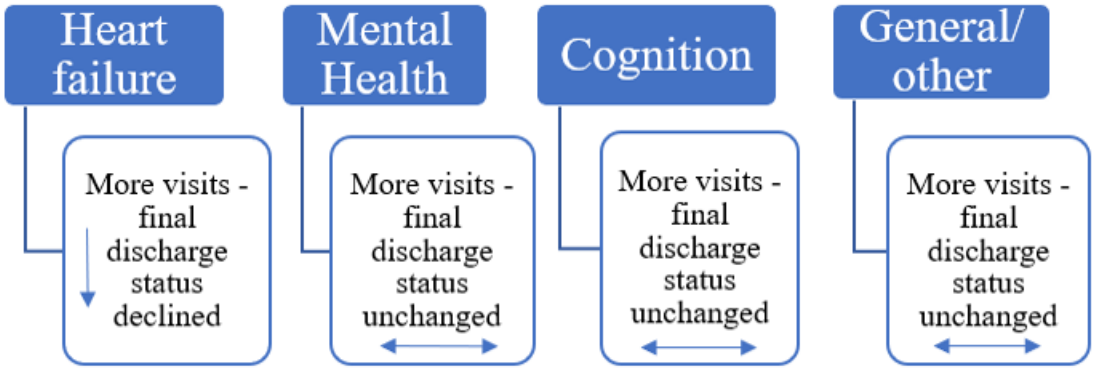


Note. Intensity is the number of interventions per visit

Figure 8 depicts the relationship of the number of visits and change in status. In the Heart Failure group more visits were negatively correlated with final discharge status. This may indicate that more visits were needed to maintain chronically ill clients over a time period until disease progression advanced, or potentially, the patient died. In the Mental Health, Cognition, and General/Other groups, more visits left did not change final status.

Figure 8

Number of visits and change in status



Summary

It was determined through literature review that many of the signs and symptoms for heart failure were found in the Omaha System Problem 28 – Respiratory and Problem 29 – Circulation. These two problems were used in the initial data query which resulted in 4,215 individuals who had signs and symptoms of these Omaha System problems.

Due to the overwhelming numbers of three signs and symptoms, decreased muscle strength, expresses discomfort/pain, and edema, these signs and symptoms obstructed further group identification, and were excluded from the second LCA. After applying these exclusionary criteria and using LCA for a second time, four major groupings of signs and symptoms became apparent. They are Heart Failure, Mental Health, Cognition, and General/Other.

Demographics of the sample were average age 76.4 years, 44% male, 31% married, and minority status/race of 62% non-Hispanic, white, 30.7% unknown, and 7.2% reporting as a member of a minority. Demographics of each group revealed that the Cognition group had the oldest clients at 79.1 years, while the General/Other group had the youngest clients at 72.1 years. Male gender was highest in the General/Other group

and lowest in the Mental health group. Gender was not statistically significant between groups. The Heart failure group had the highest minority representation at 15.6% while the Cognition group had the lowest at 3.4%. Minority data had a considerable amount of "unknown" minority status. There was no significant difference between the groups for marital status.

Problems related to physiological systems function had the highest results for all groups although to a lesser degree for the Cognition group.

The KBS mean change scores showed that the Cognition group achieved the highest positive change in Knowledge, the highest positive change value in Behavior, and the highest change in overall Status. The Mental Health group had the lowest change scores across the KBS concepts.

The Heart Failure group had the highest number of both visits and interventions followed by the Mental health group, and the Cognition group. The General/Other group had the least number of visits and interventions.

Despite the highest number of visits and interventions, the Heart Failure group attained a negative correlation between visits and final outcomes while the General/Other group maintained a nearly flat KBS score. The Cognition group benefited the most from increased visits and interventions with increased scores in all 3 concepts: Knowledge, Behavior, and Status. The Mental Health group did not demonstrate increase in KBS with increased visits and interventions which left final discharge status unchanged. The percent change in KBS scores between groups were found to be small 0.05 to 0.19 but were still considered to be in the direction of improvement or positive.

Change in interventions and outcomes by group again were found in parametric testing to be statistically significant for the General/Other and Cognition groups but non-significant for Mental Health and Heart Failure groups. The Cognition group had the best discharge status outcomes of the groups correlated to interventions and intensity of interventions.

Despite having the most visits and interventions, Heart Failure patients did not improve. On the other hand, because there were so may visits and interventions, it could suggest that the Heart Failure group was successfully maintained in the community care environment for perhaps as long as several years. Because reason for discharge is not documented in this data base, the outcome of the Heart Failure group remains undetermined.

In Chapter 5, discussion of the data analysis as related to the aims and questions of this study will be combined with literature review results to provide answers to these aims and questions.

Chapter 5

Discussion

The purpose of this study is to determine in a community care environment for a population age of 50 years of age and older if the signs and symptoms of heart failure described in the literature were actually found in the database of community health patients for years 2013 - 2018. If the signs and symptoms (s/s) present in the literature indicative of heart failure were found in this database, this would support what was found in the literature. However, since this is a secondary data analysis, the goal was to also see if other signs and symptoms or groups of signs and symptoms were present in the data that is unique to the community care environment that may help anticipate earlier onset of heart failure or exacerbation of symptoms. If signs and symptoms of heart failure were not apparent, what signs and symptoms were found and to what magnitude/degree? The results of this data analysis based on LCA and post hoc analysis further our understanding of the signs and symptoms present in the community care environment indicating heart failure and if there is an association between the patient's condition and the frequency of visits and interventions. Early detection of the signs and symptoms of heart failure could help prevent or delay further permanent cardiac damage, stabilize the client's quality of life, and reduce the health care economic burden.

As the conceptual framework for this study, the Omaha System consists of signs and symptoms organized into 42 Problems. Many of the signs and symptoms of heart failure discovered in the literature review were able to be queried directly in the database. Some of the signs and symptoms such as orthopnea or patient weight were not able to be directly queried as the Omaha System is not constructed to record these and other values.

A query of the community care database at the University of Minnesota Center for Nursing Informatics was performed using signs and symptoms related to the Omaha System Problems 28 - Respiration and Problem 29 – Circulation, which contain the highest frequency of signs and symptoms of heart failure discovered in the literature review. First database query from the Respiration and Circulation Problems for signs and symptoms of heart failure available in the database including abnormal blood pressure, rapid or slow heart rate, edema, shortness of breath/dyspnea, and abnormal breath sounds/rales. This means that the entire sample for this analysis had some signs and symptoms of heart failure. LCA was used to determine, in addition to the signs and symptoms of heart failure, if there any additional "hidden" signs and symptoms which could be grouped into Omaha System Problem identified groups. In the first LCA three signs and symptoms, decreased muscle strength, expresses discomfort/pain, and edema were so prevalent in the entire sample they obscured further discovery of any additional groups. These signs and symptoms were removed and a second LCA analysis was performed to see if the database could now reveal any discriminate groupings. Four distinct groupings of signs and symptoms emerged relative to the Omaha System Problem names. The first group was identified as Group 1, which was labeled as Heart failure as the number of signs and symptoms of heart failure such as abnormal blood pressure reading, abnormal breath patterns/dyspnea, abnormal breath sounds/rales, syncopal episodes (fainting)/dizziness, excessively rapid heartbeat and edema were reported with greater frequency than in the other groups. All groups had signs and symptoms of heart failure, but this group had the highest number of signs and symptoms of heart failure. Group 2 was labeled as Mental health as the predominant signs and

symptoms of sadness/hopelessness/decreased self-esteem, loss of interest/involvement in activities/self-care and somatic complaints/fatigue are in the Omaha System Mental health Problem Classification Scheme. Group 3 – Cognition, was labeled Cognition as the increased signs and symptoms of diminished judgment, limited recall of recent events, limited calculating/sequencing skills are in the Cognitive Problem Classification Scheme. Group 4 – General/Other was labeled as the General/Other group as there were no dominant signs and symptoms in sufficient numbers to classify them in a group. Discussion of the findings of this data analysis follows.

Aim 1

Describe demographics, service characteristics, and outcomes of the sample of adults ages 50 and older with one or more signs/symptoms included in the heart failure algorithm.

Question 1.1 – What are the demographics characteristics of this sample? The sample consisted of 4215 members with a mean age of 76.4 years. Females were 55.9, 30.7% were married with 69.3% being of single status for any reason. Reported minority status was 7.2% while non-Hispanic, white individuals comprised 62.1%.

Question 1.2 – Which of the 42 Omaha System problems were documented for the sample? The analysis identified 37 of the 42 problems associated with the Omaha System Problem schema occurring in the sample.

Question 1.3 – What were Knowledge, Behavior, and Status (KBS) scores for the sample? The Knowledge, Behavior, and Status (KBS) scores are based on a 5-point Likert scale, with 1 being the lowest score and 5 being the greatest. Each concept, Knowledge, Behavior and Status was evaluated upon admission to determine the

patient's understanding of their Problems and Interventions. For example, if a patient knew the basic information about heart failure and knew that they had to take medications daily and on time, they may score a "4" on knowledge of the Problem of Medication Regimen. However, they may not follow the prescribed medication regimen on behavior by taking their medications correctly and on time. Their behavior concept score would be a "2". Their status upon admission was a 2.5 because despite knowing which medications to take and when, they are not following the medication regimen prescribed for them, and their physiological response is deteriorating.

Knowledge scores ranged from 3.07 for medication regimen to 3.88 for reproductive function on admission. On discharge, the Knowledge scores ranged from 3.10 for Role change to 3.88 for Reproductive function.

Behavior scores ranged from 3.41 for Role change to 4.68 for Reproductive function on admission. On discharge, the Behavior scores ranged from 3.46 for Role change to 4.66 for reproductive function. Status scores ranged from 3.10 for Grief to 4.93 for Neighborhood/workforce safety. On discharge, the status scores ranged from 3.16 for Grief to 4.93 for Neighborhood/workforce safety and Reproductive function.

1.3.1 What is the change in Knowledge, Behavior, Status (KBS) from admission to discharge per problem? In this study, there were no large changes in the KBS scores indicating a substantial change from admission to discharge. The status score demonstrated the greatest positive change from admission to discharge were found in the Neuro-musculo-skeletal Problem having 0.20 Status change. This data indicates that improvement, no matter how small, is still improvement. At the very least, small improvement demonstrates stability which is still maintaining the patient in the

community care environment successfully. The greatest negative change in the sample was in the Family planning Knowledge scale with -0.40 change. In the sample only five data point entries on the Family planning Problem were recorded so the results may be skewed by one person answering in a lest knowledgeable fashion.

Question 1.4 – What service characteristics (interventions and visits) were documented for the sample? The mean number of visits per person was 49. The mean number of interventions per person in the sample was 622. That calculates to 12.69 interventions per visit. While this may be a considerable number of interventions per visit, this indicates each visit required considerable effort to keep the patient stable indicating that the patients had multiple problems and possibly multiple chronic conditions. This study did not investigate which problems were present and their association to chronic disease processes and may be an area worth further research in the future.

Question 1.5 – What problems/signs and symptoms were documented for the sample? The most frequent signs and symptoms of decreased muscle strength (n = 2600), expresses discomfort/pain (n = 2559), and edema (N = 2382) represent 36.3% of the total signs and symptoms (n = 20,766) reported. Each of these three signs and symptoms were reported by 61.68%, 60.71% and 56.54% of the patients respectively. Many of the other signs and symptoms such as difficulty hearing normal speech tones, difficulty seeing small print/calibrations reflect signs and symptoms of aging. Clearly, the pure numbers of signs and symptoms suggest that the sample population has several comorbidities occurring simultaneously.

The discovery of high number of reported signs and symptoms in the data of the entire sample of decreased muscle strength 2600 (61.68%) along with expression of discomfort/pain with 2559 (60.71%) and presence of edema with 2383 (56.54%) suggests lack of activity and debilitation across the entire sample. While the reason for initiating community care is not known for this study, the overwhelming numbers of these three signs and symptoms indicate the possibility of acute or acute on chronic disease processes were also presenting. Other signs and symptoms found in the sample include Urinary incontinence with 1330 (31.55%), abnormal blood pressure reading with 1138 (28.09%) followed by lesion/pressure ulcer 1141 (27.07%), and abnormal breath patterns/dyspnea 1138 (27.0%). Abnormal breath patterns with 997 (23.65%), as well as abnormal frequency/consistency of stool with 962 (22.82%) were also noted. The other signs and symptoms were reported under 20% of the time including excessively rapid (211, 5.01%) and slow (98, 2.33%) heart rates which the review of the literature indicated to be respectively the second and third most prevalent signs and symptoms of heart failure. This data analysis does not support those findings.

Aim 2 - Discover groups within the sample described in Aim 1 using latent class analysis (LCA).

The literature review established the most frequent signs and symptoms of heart failure, which were rapid heart rate, slow heart rate, abnormal blood pressure, actual patient weight (+/- 4 lbs.), abnormal breath sounds – dyspnea, and edema, which became the basis of the determining the sample. As a matter of clarification, all patients included in the sample had at least one sign and symptom of heart failure. The first LCA performed resulted in three highly prevalent signs and symptoms; decreased muscle

strength, expresses pain/discomfort, and edema. These signs and symptoms overwhelmed any further group discrimination and were excluded from the second LCA. The second LCA revealed in four distinct groups. The groups were named after the predominance of other signs and symptoms related to an Omaha System Problem. One group had significantly higher heart failure signs and symptoms and was named the Heart failure group. The other groups were labeled the Mental health group, the Cognitive group, and the remainder of the sample labeled as General/Other.

Question 2.1 – What are the demographics characteristics of each group? The Cognition group had the highest mean age of 79.1 years. The Heart failure group was relatively young at 74.2 years. There was no statistically significant difference between groups for gender or marital status.

Minority status was significant for non-minority individuals having a greater percentage of the sample population in all groups. There was a significant amount of reported “unknown” minority status. As was noted in research by Nayak et al., (2020) minority status could be an important factor in prescribing some medications. While the general community health nurse may not prescribe medications, being cognizant of minority status and medication prescription efficacy or ineffectiveness for certain races and ethnicities needs to remain at the forefront. The database used for this study did not provide more detailed information on the race and ethnicity of individuals. This research is unable to establish any further data analysis other than most of the reported minority status was non-minority. This also raises the question of access to care as being a reason for low reported minority status. It is not known what the population demographics are so

further study is necessary to determine if access to care issues may be present for individuals from minority backgrounds from this database catchment area.

Question 2.2 – Which of the 42 Omaha System problems were documented for each group? For the study focus the Omaha System Problem 28 – Respiration and Problem 29 – Circulation, the Heart failure group reported signs and symptoms of the Respiration Problem in 73% of the group and signs and symptoms of the Circulation Problem in 87% of the group. The Mental health group reported signs and symptoms of the Respiration Problem in 62% of the group and signs and symptoms of the Circulation Problem in 78% of the group, the Cognition group reported signs and symptoms of the Respiration Problem in 28% of this group and signs and symptoms of the Circulation Problem in 45% of the group, and the General/Other group reported signs and symptoms of the Respiration Problem in 50% of the group and signs and symptoms of the Circulation Problem in 79% of the group. The signs and symptoms from the Mental health Problem were reported in 70% of the Heart failure group and 88% of the Mental health group. This is supported by the literature (Angerman & Ertl, 2018; Cully et al., 2009; Thompson et al., 2015; Smets et al., 2018).

Question 2.3 – What were Knowledge, Behavior, and Status (KBS) scores for each group? For the Heart failure group, the mean admission Knowledge score was 3.11 and the mean discharge Knowledge score was 3.18. The mean admission Behavior score was 3.43 and the mean discharge Behavior score was 3.47. The mean admission Status score was 3.34 and the mean discharge Status score was 3.40.

For the Mental health group, the mean admission Knowledge score was 3.15 and the mean discharge Knowledge score was 3.19. The mean admission Behavior score was

3.56 and the mean discharge Behavior score was 3.61. The mean admission Status score was 3.50 and the mean discharge Status score was 3.55.

For the Cognition group, the mean admission Knowledge score was 2.95 and the mean discharge score was 3.12. The mean admission Behavior score was 3.52 and the mean discharge Behavior score was 3.69. The mean admission Status score was 3.16 and the mean discharge Status score was 3.35.

For the General/Other group, the mean admission Knowledge score was 3.25 and the mean discharge Knowledge score was 3.36. The mean admission Behavior score was 3.75 and the mean discharge Behavior score was 3.84. The mean admission Status score was 3.58 and the mean discharge Status score was 3.72.

For the groups, the lowest score was with the Cognition group with mean admission Knowledge at 2.95. The highest score was with the General/Other group with mean discharge Behavior at 3.84.

Question 2.3.1 What is the change in Knowledge, Behavior, Status (KBS) per group from admission to discharge per problem? The same KBS assessment was given to clients who were discharged from the service. The change in KBS per group from admission to discharge were for Heart failure, Knowledge changed 0.07, Behavior changed 0.05 and Status changed 0.05. For Mental health, the change in KBS scores from admission to discharge was 0.05 for Knowledge, 0.05 for Behavior, and 0.05 for Status. For Cognition the change in KBS scores from admission to discharge were 0.17 for Knowledge, 0.17 for Behavior, and 0.19 for Status. For the General/Other group, the change in KBS scores from admission to discharge ranged from 0.11 for Knowledge, 0.09 for Behavior, and 0.13 for Status. The change between admission and discharge is

small but in a positive direction indicating, at the very least, status stability in the community care environment.

Question 2.4 – What service characteristics (interventions and visits) were documented for each group? The entire sample consisted of 4215 observations. Visits and interventions were found in 4208 of the observations.

The Heart failure group had the greatest number of mean visits (n = 58.6) and interventions (n = 1353.1). The Mental health group had the second most mean visits (n = 54.3) and interventions (n = 772). The Cognition group had the third most mean visits (n =51.7) and interventions (n = 723.2). The General/Other group had the least mean visits (n = 45.8) and interventions (n = 445.5).

The interventions per visit, a calculation of the mean number of interventions per mean number of visits showed that the intensity of the visits for the Heart failure group was 23.09 interventions per visit. For the Mental health group the intensity of the visits was 14.2. For the Cognition group, the intensity of the visits was 13.99. For the General/Other group, the intensity of the visits was 9.7. This indicates that the Heart failure group required more interventions each visit suggesting that this group was group was sicker than the rest of the groups.

Question 2.5 – What signs and symptoms and problems were documented for each of the groups? The Heart failure group demonstrated significant numbers of the heart failure signs and symptoms found in the literature, namely edema, abnormal blood pressure, abnormal breath patterns, and dyspnea. Also present in significant numbers were signs and symptoms of pain, abnormal frequency/consistency of stool, frequently

waking during the night, incontinence of urine, skin lesions, and other signs and symptoms related to being seriously ill and aging.

The Mental health group had significant numbers of signs and symptoms of sadness/hopelessness/decreased self-esteem, loss of interest in activities/self-care, somatic complaints such as fatigue, but did not demonstrate an increase in reported expressed suicidal/homicidal thoughts.

The Cognition group had significant numbers of signs and symptoms of diminished judgement, limited recall of recent events, and limited calculating/sequencing skills. This group also had signs and symptoms associated with lesions/pressure ulcers, hydration and anorexia, abnormal frequency/consistency of stool and urinary incontinence. These signs and symptoms indicate that the patient's mental faculties may not make them aware that they have sat in the same position for a long period of time, or have not had enough to drink, or are cognizant of their bowel and bladder functions. Pain and difficulty with Neuro-musculoskeletal function mobility factors may make getting to bathroom facilities painful and/or difficult contributing to the increased numbers of these signs and symptoms within this group.

The General/Other group had significant numbers of signs and symptoms of the heart failure signs and symptoms including edema, but generalized signs and symptoms of pain, decreased muscle strength, skin lesions/pressure ulcers, abnormal frequency/consistency of stool, hydration and anorexia, and urinary incontinence.

Aim 3 – Compare service characteristics (interventions/visits) and outcomes for each of the groups identified in Aim 2.

The Heart failure group had the second most patients of the sample and had the highest mean number of visits and interventions. This indicates that these patients were much sicker requiring more intense and frequent services. The Heart failure group did not demonstrate any statistical significance of outcomes to interventions ($p < 0.959$). KBS change scores reflected a small change in discharge status scores ($K = 0.07$, $B = 0.05$, $S = 0.05$)

The Mental health group had the second-highest number of visits and interventions and demonstrated statistical significance ($p < 0.001$) with admission to discharge change KBS scores which were consistently 0.05.

The Cognition group had the least number of visits and interventions and had a statistically significant ($p < 0.001$) and consistent improvement in admission to discharge KBS change scores. The change in KBS scores from admission to discharge were small, ($K = 0.17$, $B = 0.17$, $S = 0.19$) but an improvement none-the-less. For this group a little assistance and support offered improvement in their outcome KBS discharge scores.

The General/Other group had the greatest portion of the sample yet had the fewest mean visits and interventions. Their discharge status outcome improvement was statistically significant ($p < 0.001$) admission to discharge KBS change scores were $K = 0.11$, $B = 0.09$, and $S = 0.13$; a small increase.

However, Heart failure and General/Other did not demonstrate significant positive outcomes despite having the highest number of visits and interventions. Correlated with the lack of significant change in the KBS scores could mean that the community care providers maintained chronically and acutely ill clients for a long period of time in the community care environment.

Question 3.1 – Which intervention characteristics were associated with the best outcomes and overall by group? Despite more interventions and visits, final status remained basically unchanged except for the Heart failure group where a negative correlation between the increased number of visits and final status was found. As a chronic, progressive condition, heart failure clients would logically experience exacerbations of their condition and experience decline over time. The number of interventions and visits also suggest that these clients were also taken care of in the community care setting for a considerable amount of time, potentially years. From a quality-of-life perspective, being maintained in one's home and community is far more desirable that in a long-term care facility or a hospitalization. From a purely economic perspective, community care nursing visits are much less expensive to the healthcare system than a hospitalization or long-term skilled nursing facility (SNF) care.

In this analysis, interventions improved outcomes for Mental health and Cognition but not for Heart failure and General/Other. Mental health has a positive correlation at discharge. For Cognition, more interventions produced a greater positive change in discharge status using a non-parametric (Spearman) correlation test. Final discharge status for General/Other was basically unchanged indicating that their status was maintained. Heart failure was slightly negatively correlated indicating the chronic disease process was progressing despite the highest number of visits and interventions of all the groups.

What this study did demonstrate is that the chronic nature of heart failure can be managed in the community care setting as demonstrated by the mean number of visits and interventions being the largest in the Heart failure group. Because duration of

services or episodes of care information was not available, it was not possible to evaluate how long heart failure patients were managed successfully in the community care setting. Without discharge reason information, the reason why patients left the community care services is not known. The slight decrease in discharge status suggests that chronic disease progression necessitated more intense care or that the patient died.

The Omaha System framework and the PIO-MM model were crucial in obtaining and validating the data for this study.

Implications for future research

The data demonstrated that the Heart failure group had more visits and interventions with stable to slightly worse final discharge status without significant improvement. Stability is a success because the client did not worsen and require further interventions or hospitalization. The future question which may help guide nursing practice is why was the patient discharged from care? Did they reach the end of their number of approved visits by Medicare? Did they die? Did they suddenly become so ill that they did require hospitalization and then post-acute care transfer to a SNF? Were they moved by family members out of the community care catchment area where services could not be continued?

Additional research into when the intensity of the visits increased or decreased and at what point in the continuum? Were more visits needed at the beginning of care and taper off or did the reverse take place? The addition of the date of visits as a data collection point would offer some insight into the intensity of visits and interventions compared to KBS scores such that if status scores were dropping, increasing the number

of visits and interventions would be justified and necessary to maintain the patient in the community care environment.

The close association between the Heart failure group and the Mental health group suggests that Mental health is a concern for heart failure patients and should be part of the initial evaluation process, including evaluating for suicide. Liu et al., (2018) state the risk of suicide is particularly higher during the first 6 months after initial heart failure diagnosis and adequately managing mental illness for heart failure patients would help reduce mortality.

Further research into why there were overwhelming signs and symptoms of decreased muscle strength, expresses discomfort/pain, and edema in the community care environment should be done. This database could not provide information needed to determine why a high prevalence of these signs and symptoms existed. However, these signs and symptoms on their own may not constitute a substantial reason for community care services. Further research into what other underlying conditions may be occurring would be needed.

This supports my rationale to include the medical admission and discharge diagnoses in the data. This would enable the ability to potentially associate signs and symptoms with the reasons why the community care was ordered. Although this study is viewed through the nursing lens, patient care is not only nursing specific. That is why the suggestion to include the medical admission and discharge diagnoses would be helpful in coordinating best care practices, including nursing specific observations and treatments of Omaha System Problems executed through the PIO-MM model would be much more effective. As many US reporting systems use largely standardized coding sets, this would

also be a way for nursing care services to be more fully integrated and recognized as critical members of the healthcare continuum.

The LCA discovery of Mental health and Cognition signs and symptoms demonstrate a correlation between the disease processes and Heart failure signs and symptoms. Which came first, the Mental health signs and symptoms, or did the Heart failure cause the Mental health signs and symptoms to occur? The same could be said regarding the Cognition signs and symptoms. Did they occur as a result of the heart failure signs and symptoms or were cognitive changes already occurring that exacerbated heart failure signs and symptoms? Or, is it the nature of Heart failure to have Mental health and Cognition signs and symptoms? Further research into why this correlation exists would need to be performed. Using the Omaha System in its entirety would encompass the Mental health and Cognitive assessments necessary to assist in this research.

Another area of research is to evaluate signs and symptoms of heart failure in clinical narrative notes using natural language processing shows promise in Heart failure management. Meystre et al., (2017) demonstrated “applying natural language processing to unlock the rich and detailed clinical information found in clinical narrative text notes makes fast and scalable quality improvement approaches possible, eventually improving management and outpatient treatment of patients suffering from CHF” (p. e40). The possibility of routing the clinical text to the Omaha system could provide a wealth of supporting information to include in the Omaha System assessment and evaluation process through Monson’s (2018a) PIO-MM model.

These are all questions for future research, which may require acquiring more admission and discharge information for community care services to answer these questions.

Implications for practice

Currently, nursing care delivered to patients in the community care environment have a medical reason to receive care in this environment. To determine whether the prescribed care is working or not, you must have an evaluation system that is nursing sensitive. The Omaha System framework is nursing sensitive and provides an excellent structure to document problems identified, services or support rendered, and how those services and support impacted the outcomes of the patient. The outcomes are evaluated and documented by the KBS scores. Did the patient get better or worse? Was the patient able to be safely and successfully discharged from community care nursing and remain stable in the community care environment of their choice? Without overly burdening the nurse with documentation tasks, the Omaha System integration into the EHR would provide the documentation guidance and flow necessary to provide outcomes supporting efficacy with positive change in KBS or the need for further care a negative change in KBS scores or physiological worsening of condition.

Numbers speak volumes in healthcare today. To get “the numbers” to support the work and effectiveness of the care provided in the community care setting, the data collection systems should be standardized in nursing sensitive care descriptions, systems updated regularly as research updates disease management, and core physiological information be universal. For example, this would include adding patient weight and height to the Omaha System to support the management of chronic diseases such as heart

failure and chronic kidney disease as universal elements of all data collection and medical record systems. This lack of standardization means we cannot truly get the entire information regarding chronic disease management because not all data points are being captured in a consistent universally agreed upon fashion. This also makes it difficult to determine what works with treatments and interventions for certain chronic disease and what does not.

Furthermore, by not asking the patient-reported outcomes questions, we miss the opportunity to determine if other data points, such as the SDOH, which may influence a patient's ability to overcome or defer heart failure deterioration. Without this information, clinicians are unable to adjust their practice or obtain assistance for the patient to meet the treatment guideline recommendations established in the hospital environment that must initially carry over into the community care environment. How can you measure the impact of community issues on the patient if clinicians do not ask the questions? How can they remember all the questions necessary to ask that may impact the heart failure patient's health and wellbeing? They need a tool, instrument, metric, or guideline that is all-encompassing both the clinical and Social Determinants of Health. It is recommended by this researcher to incorporate the multifactorial and multidimensional Omaha System within EHRs and run a developed algorithm of the seven cardinal signs and symptoms of heart failure and the recommended non-clinical signs and symptoms against real-time recorded patient assessment data based on the Omaha System problems list. The results would be reported in a "heart failure status score" alerting the provider of the need for early intervention, either clinical or non-clinical. This clinical database could also have another query based upon clinical diagnoses assigned to heart failure to query

the EHR database in real-time to discover new and emerging signs and symptoms of heart failure resulting in updated evidence-based practice.

Policy implications

The implications for nursing and community care practice could be significant if the regulations surrounding Medicare coverage of home health visits were guided not by the number of visits allowed per episode of care, but by the condition of the patient. In many respects, having a chronic disease costs a lot economically, in the quality of life for the client, and on families attempting to care for their loved one with a chronic disease such as heart failure. If the goal is to maintain clients safely in their homes and reduce hospital readmissions, then an examination of the policies and reimbursement practices surrounding home health/community care of chronic disease processes needs to take place. It serves no purpose to give nurses knowledge and skill and then tell them they cannot use them to keep their clients with chronic diseases healthy and safe with a good quality of life because the number of allotted visits has been used up and services must either stop or be paid for out of pocket.

Recommendations

For documentation of quality of care provided, a discharge reason would provide information regarding why the patient left the community care services. Information regarding services provided include, finances, out of allotted Medicare covered days leaving the client to be self-pay, general deterioration necessitating more supervised care such as admission to a SNF, worsening condition necessitating hospitalization, or even death of the client, could be reasons for discharge from this community care service provider. These variables are beyond the control of the community care provider but

knowing this information would allow for benchmarking and quality of service controls. Just having a discharge date and KBS rating gives no information as to why the services were stopped. If the reason happens to be that the client's Medicare coverage has utilized all 30 available days, but the client would still benefit from continued visits and interventions, are we not exacerbating a problem that the health care professionals fought so hard to assist getting the client to the current level by prematurely stopping services? This study suggests that clients can be maintained in the community care setting for long periods of time. There may not be improvement in the client's condition but remaining stable is considered a positive outcome.

The Omaha System and algorithmic analyses

The use of the Omaha System framework in this research was found to be a highly effective, nursing-sensitive, holistic, and comprehensive assessment and documentation tool. Potential pilot projects where actual holistic nursing evaluations utilizing Omaha System Problems, Interventions and Outcomes for early identification of signs and symptoms associated with a disease process could prove to be cost effective and provide a good quality of life for the patients.

This further brings to the forefront the importance of standardized nursing-sensitive documentation is to clinical care as well as data abstraction and analysis. For example, the Omaha System contains sign and symptom for "abnormal breath sounds." If abnormal breath sounds includes rales, orthopnea, and wheezing, the slight discrimination between what may be cardiovascular connected (rales and orthopnea) versus respiratory-related (wheezing) would be helpful in documenting same status or a new respiratory problem. Standardized nursing-sensitive documentation would further

future statistical analysis that supports nursing efforts and results. In this study, the Omaha System was found to be very helpful in organizing the data for analysis in a logical and systematic manner, however, some "updating" of the Omaha System signs and symptoms discrimination as well as inclusion of height and weight to BMI calculation would lend value to the system. Future improvements for greater incorporation in electronic health records would help to improve nursing practice.

To assist care providers in the community care environment, if an algorithm could be created using the Omaha System framework as a basis to create data necessary to be evaluated by an algorithm to determine early signs and symptoms of heart failure are presenting, care could be altered to protect both the physiological implications of worsening heart failure and maintain the patient's quality of life in the community care environment. Blecker et al., (2016), found that current inpatient problem lists are not sufficient for real-time identification of hospitalized patients with heart failure and recommended the use of machine learning analytics, such as algorithms, in future EHR systems which would improve heart failure cohort identification in the inpatient environment. Choi et al., (2017) also found deep learning methods improved incidental initial heart failure diagnosis detection over a 12 -18-month window in outpatient EHR data. An algorithm running in real-time identifying these heart failure signs and symptoms while the primary care provider is available would allow for communication with the physician in charge and allow for treatment orders to be altered or other options utilized such as hospitalization. This algorithm development would also help the community care provider to have instantaneous helpful information when time and resources are available.

Limitations

Limitations in this study include the nature of secondary data analysis on a data set that was not designed specifically for the questions being asked and may have multiple explanations for the results. Key data which could strengthen the validity of the groups created by this study, such as admission diagnosis, or a diagnosis of heart failure, or the patient's weight, are missing because it is not included in the data collection mechanism designed for this sample. However, this dataset is a sample based off community care visits and interventions that were provided in response to the client's signs and symptoms reporting. The goal was to evaluate this existing database, designed for another purpose, research, or study to identify if any other patterns or groups related to heart failure signs and symptoms could be observed.

Limitations were encountered regarding time between admission and discharge. Questions regarding how long the patients were in the community care database could not be answered. How many visits per month or week could not be determined because the data was not available.

Another limitation related to this is an absence of discharge reason. Did the client get well and no longer need services or did the client deteriorate and require hospitalization? Did the client's number of Medicare approved visits run out necessitating discontinuance of services still clinically necessary? Did the client move out of the community care's catchment area and were no longer serviced by these providers? Did the patient die? The lack of these data points limits how specific the data can be correlated over time, the intensity of the visits at certain points in the service trajectory, and why the client left the care of this community care organization. This could be used

as future services justification if historical precedence demonstrates condition stability or better yet, improvement.

It would be helpful if the medical diagnosis of heart failure would have been available to clearly identify the patients in the database with heart failure. It would also confirm with the signs and symptoms found that the association between the signs and symptoms and the medical diagnosis were what was found in the literature.

Recommendations for future community care Heart failure tool EHR development

The lack of one instrument, tool, metric, or guideline that was all-encompassing of all the cardinal signs and symptoms indicative of worsening heart failure in the early stages of decompensation where it is most easily treatable suggests that community-based providers may be at risk of missing important clues to a patient's heart failure deterioration. Furthermore, by not asking the patient-reported outcomes questions, we miss the opportunity to determine if other data points, such as the SDOH exist which may influence a patient's ability to overcome or delay heart failure deterioration. Without this information, clinicians are unable to adjust their practice or obtain assistance for the patient to meet the treatment guideline recommendations established in the hospital environment that must initially carry over into the community care environment. How can you measure the impact of community issues on the patient if clinicians do not think to ask the questions? How can they remember all the questions necessary to ask that may impact the heart failure patient's health and wellbeing? They need a tool, instrument, metric, or guideline that is all-encompassing for both the clinical and SDOH areas. If the Omaha System were incorporated within EHRs, an algorithm created based on the seven cardinal signs and symptoms of heart failure found in the review of the literature

(abnormal blood pressure reading(s), excessively rapid heart rate, excessively slow heart rate, patient weight changes, BMI, dyspnea, and edema) correlated with signs and symptoms from the Mental health and Cognitive Problems, a real-time "heart failure status score" could be generated alerting the provider the need for intervention based on the signs and symptoms present.

The results of this study suggest that clients in the community care environment have classical signs and symptoms of heart failure and some signs and symptoms of Mental health and Cognitive changes which, if addressed early in their presentation, may offer the client a longer period of less severe symptoms and a better quality of life. Policies surrounding home health care, particularly the number of allotted visits, should be examined for efficacy versus hospitalizations. As a society, do we want to pay for care now where home health treatment is most effective in maintaining the patient's status longer, or do we agree that this is not necessary? If the patient worsens, it is because it is unavoidable, and we are willing to pay for acute care treatment as many times as it is necessary to stabilize the patient? These hard questions need to be addressed and policies, particularly those surrounding Medicare continuing care guidelines for care continuum and reimbursement must be updated accordingly.

Further refinement of data collection software and EHR capabilities would enhance data collection and analysis. Examples of this would be to incorporate weight, which is critical to the management of heart failure, and height necessary to calculate BMI for the management of obesity and other chronic diseases. Use of analyses such as LCA allows researchers to "slice and dice" the data to uncover the hidden secrets the data can show us. However, if the data points are not collected and adequately aggregated,

then important clues to the disease process may remain hidden and correlations between data points cannot be made. Further research into “before and after” improvements to software design and data capture would be needed to determine if this is so.

While this study did not definitively demonstrate that more visits and interventions improved outcomes in heart failure patients, it did indicate by the total number of total visits and interventions in the 2013 – 2018 date span successfully maintained these patients for a considerable amount of time in the community care setting. Time or duration was not measured in this study as this is an observational study and not longitudinal in nature. This study also found the Mental health and Cognitive groups had significant signs and symptoms of heart failure. The implication of this correlation requires more research to fully understand. It is apparent, that initial assessment of the patient being evaluated for worsening heart failure include assessing for the presence of Mental health and Cognitive signs and symptoms. Instituting safety protocols, notifying the prescribing provider of these conditions could lead to greater outpatient and community care stabilization and better quality of life for the heart failure patient.

References

Amarasingham, R., Patel, P., Toto, K., Nelson, L., Swanson, T., Moore, B., Xie, B., Zhang, S., Alvarez, K., Ma, Y., Drazner, M., Kollipara, U., & Halm, E. (2013). Allocating scarce resources in real-time to reduce heart failure readmissions: a prospective, controlled study. *BMJ Quality & Safety. 22*(12), 998-1005. https://doi.org/10.1136/bmjgs-2013-002407

American Heart Association (AHA). (2019). Classes of heart Failure. http://www.heart.org/HEARTORG/Conditions/HeartFailure/AboutHeartFailure/ClassesofHeartFailure_UCM_306328_Article.jsp?appName=MobileApp

Angermann, C. & Ertl, G. (2018). Depression, anxiety, and cognitive impairment – Comorbid mental health disorders in heart failure. *Current Heart Failure Reports, 15*, 399 – 410. https://doi.org/10.1007/s11897-018-0414-8

Banerjee, D., Thompson, C., Kell, C. Shetty, R., Vetteth, Y., Grossman, H., DiBiase, A., & Fowler, M. (2017). An informatics-based approach to reducing heart failure all-cause readmissions: The Stanford heart failure dashboard, *Journal of the American Medical Informatics Association, 24*(3), 550 -555. https://doi.org/10.1093/jamia/ocw150

Blecker, S., Katz, S.D., Horwitz, L.I., Kuperman, G., Park, H., Gold, A., & Sontag, D. (2016). Comparison approaches for heart failure case identification from electronic health record data. *JAMA Cardiology, 1*(9), 1014-1020. https://doi.org/10.1001/jamacardio.2016.3236

Byrd, R., Steinhubl, S., Sun, Ebadollahi, S., & Stewart, W. (2014). Automatic identification of heart failure diagnostic criteria, using text analysis of clinical

notes from electronic health records, *International Journal of Medical Informatics, 83*, 983 - 982. https://doi.org/10.1016/j.ijmedinf.2012.12.005

Cagle, K., (2019). Taxonomies vs. ontologies. *Forbes.* https://www.forbes.com/sites/cognitiveworld/2019/03/24/taxonomies-vs-ontologies/#471518897d53

Carvalho, V., Bocchi, E., & Guimaraes, G. (2009). The Borg scale as an important tool of self-monitoring and self-regulation of exercise prescription in heart failure patients during hydrotherapy. A randomized blinded controlled trial. *Circulation Journal. 73*(10), 1871 - 1876. https://doi.org/10.1253/circj.CJ-09-0333

Casey, T. (2017). Readmissions for acute MI, heart failure are expensive, lead to long hospital stays. *Healthcare Economics and Policy.* https://www.cardiovascularbusiness.com/topics/healthcare-economics/readmissions-acute-mi-heart-failure-are-expensive-lead-long-hospital

Centers for Disease Control and Prevention (CDC), 2020. Heart Disease; Heart Failure. https://www.cdc.gov/heartdisease/heart_failure.htm#:~:text=About%206.5%20million%20adults%20in%20the%20United%20States%20have%20heart%20failure.

Choi, E., Schuetz, A., Stewart, W., & Sun, J. (2017). Using recurrent neural network models for early detection of heart failure onset. *Journal of the American Medical Informatics Association, 24*(2), 361-370. https://doi.org/10.1093/jamia/ocw112

Colby, S. & Ortman, J. (2014). The baby boom cohort in the United States: 2012 to 2060. *Current Population Reports, United States Census Bureau P25-1141.* https://www.census.gov/prod/2014pubs/p25-1141.pdf

Conrad, N., Judge, A., Tran, J., Mohseni, H., Hedgecott, D., Crespillo, A., Allison, M., Hemingway., H., Cleland, J., McMurray, J., & Rahmi, K. (2018). Temporal trends and patterns in heart failure incidence: a population-based study of 4 million individuals. *The Lancet, 391,* 572 - 580. https://doi.org/10.1016/S014-6736(17)32520-5

Cully, J., Jimenez, D., Ledoux, T., & Deswal, A. (2009). Recognition and treatment of depression and anxiety symptoms in heart failure. *Primary Care Companion Journal of Clinical Psychiatry, 11*(3). 103-106. https://doi.org/10.488/pcc.08m00700

Fingar, K., Barrett, M., & Jiang, H. (2017). *A comparison of all-cause 7-day and 30-day Readmissions, 2014.* (Healthcare Cost and Utilization Project (HCUP) - Statistical Brief #230). Agency for Healthcare Research and Quality. https://hcup-us.ahrq.gov/reports/statbriefs/sb230-7-Day-Versus-30-Day-Readmissions.jsp

Fingar K. and Washington, R. (2015). *Trends in hospital readmissions for high-volume conditions, 2009 – 2013.* (Healthcare Cost and Utilization Project (HCUP) – Statistical Brief #196). Agency for Healthcare Research and Quality. https://www.hcup-us.ahrq.gov/reports/statbriefs/sb196-Readmissions-Trends-High-Volume-Conditions.jsp

Franchini, M., Pieroni, S., Passino, C., Emdin, M., & Molinaro, S. (2018). The CARPIDIEM Algorithm: A rule-based system for identifying heart failure phenotype with a precision public health approach. *Frontiers in Public Health, 6*(6). https://doi/org/10.3389/fpubh.2018.00006

Gao, G., Pieczkiewicz, D., Kerr, M., Lindquist, R., Chi, C. L., Maganti, S., Austin, R., Kreitzer, M., Todd, K., & Monsen, K. (2018). Exploring older adults' strengths, problems, and wellbeing using de-identified electronic health record data. *AMIA Annual Symposium Proceedings Archive*, 1263 – 1272. PMCID: PMC6371293. PMID: 30815168.

Gao, G., Kerr, M., Lindquist, R., Chi, C., Mathiason, M., Monsen, K. (2019). Discovering associations among older adults' characteristics and planned nursing interventions using Electronic Health Record data. *Research and Theory for Nursing Practice: An International Journal, 33*(1), 58 – 80. https://doi.org/10.1891/1641-6577.33.1.58

Grace-Martin, K. (2020). What is latent class analysis? *The Analysis Factor.* https://www.theanalysisfactor.com/what-is-latent-class-analysis/

Grange, J. (2005). The role of nurses in the management of heart failure. *Heart*, 91 (supplement II), ii39-ii42. https://doi.org/10.1136/hrt.2005.062117

Green, C., Porter, C., Bresnahan, D., & Spertus, J. (2000). Development and evaluation of the Kansas City Cardiomyopathy Questionnaire: a new health status measure for heart failure. *Journal of the American College of Cardiology, (35)*5, 1245 – 1255. https://doi.org/10.1016/S0735-1097(00)00531-3

Healio Learn the Heart. (2019). ACC/AHA Heart Failure Classification. https://www.healio.com/cardiology/learn-the-heart/cardiology-review/topic-reviews/accaha-heart-failure-classification

Heart Failure Society of America. (2019). Talking with your patients about heart failure – A clinician's guide.

https://staywell.mydigitalpublication.com/publication/?i=540965#{%22issue_id%22:540965,%22page%22:0}

Heart Failure Society of America (HFSA) 2020. Learn about heart failure. https://hfsa.org/patient-hub/learn-about-heart-failureM

Heidenreich, P., Albert, N., Allen, L., Bluemke, D., Butler, J., Fonarow, G., … Stroke Council (2013). Forecasting the impact of heart failure in the United States: a policy statement from the American Heart Association. *Circulation. Heart failure, 6*(3), 606–619. https://doi.org/10.1161/HHF.0b013e318291329a

Johnson, N., Hayes, L., Brown, K., Hoo, E., & Ethier, K. (2014) CDC National Health Report: Leading causes of morbidity and mortality and associated behavioral risk and protective factors – United States, 2005-2013. *Centers for Disease Control and Prevention – Morbidity and Mortality Weekly Report (MMWR), 63(04), p. 3 – 27.* https://www.cdc.gov/mmwr/preview/mmwrhtml/su6304a2.htm

Kilgore, M., Patel, H., Kielhorn, A., Maya, J., & Sharma, P. (2017). Economic burden of hospitalizations of Medicare beneficiaries with heart failure. *Risk Management and Healthcare Policy, 2017*(10), 63-70. https://doi.org/10.2147/RMHP.S130341

Lanza, S.T., Dziak, J. J., Huang, L., Wagner, A., & Collins, L.M. (2015). Proc LCA & Proc LTA user's guide (Version 1.3.2). *The Methodology Center, Penn State.* Available at: https://sites.psu.edu/pbh112/files/2019/03/proc_lca_lta_1-3-2-1_users_guide-2ggq4d3.pdf

Levy, W., Mozaffarian, D., Linker, D., Sutradhar, S., Anker, S., Cropp, A., Anand, I., Maggioni, A., Burton, P., Sullivan, M., Pitt, B., Poole-Wilson, P., Mann, D., &

Packer, M. (2006). The Seattle Heart Failure Model, 113, 1424 – 1433. https://doi.org/10.1161/CIRCULATIONAHA.105.584102

Liu, C. H., Want, J.H., Wend, S.C. Cheng, Y.H., Yeh, M.K.,Bai, M.Y, & Chang, J.C. (2018). Is heart failure associated with risk of suicide? *Journal of Cardiac Failure, 24*(11). 795 – 800. https://doi.org/10.1016/j.cardfail.2018.07.006

Maddocks, H., Marshall, J., Stewart,, M., Terry, A., Cejic, S., Hammond, J., Jordan, J., Chevendra, V. Denomme, L., & Thind, A. (2010). Quality of congestive heart failure care. Assessing measurement of care using electronic medical records. *Canadian Family Physician, 56*(12), 432 - 437. PMC3001951 PMID: 21156884. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3001951/

Mahmood, S. & Wang, T. (2013). The epidemiology of congestive heart failure: the Framingham Heart Study perspective. *Global Heart, 8*(1), 77 – 82, https://doi.org/10.1016/j.gheart.2012.12.006

Martin, K. S. (2005). *The Omaha System: A key to practice, documentation, and information management* (reprinted 2nd ed.). Health Connections Press.

Martin, K. S., Norris, J., & Leak, G. K. (1999). Psychometric analysis of the Problem rating scale for outcomes. *Outcomes Management for Nursing Practice, 3*(1). 20 – 25.

Martin, K.S. & Scheet, N.J. (1992). The Omaha System: Applications for community health nursing. WB Saunders Company.

Martinez-Gonzalez, N., Djalali, S., Tandjung, R., Huber-Geismann, F., Markun, S., Wensing, M., & Rosemann, T. (2014). Substitution of physicians by nurses in

primary care: A systemic review and meta-analysis. *BMC Health Services Research, 14*(214). https://doi.org/10.1186/1472-6963-14-214

Mbakwem, A., Aina, F., & Amadi, C. (2016). Expert opinion-Depression in patients with heart failure: Is enough being done?, *Cardiac Failure Review, 2*(2), 110-112. https://doi.org/10.15420/cfr.2016:21:1

McKinley, D., Moye-Dickerson, P., Davis, S., & Akil, A. (2019). Impact of a pharmacist-led intervention on 30-day readmission and assessment of factors predictive of readmission in African American Men with heart failure. *American Journal of Men's Health*,1-10. https://doi.org/10.1177/1557988318814295

Mcllvennan, C., Eapen, Z., & Allen, L. (2015). Hospital Readmission Reduction Program, *Circulation, 131*(20), 1796-1803. https://doi.org/10.1161/CIRCULATIONAHA.114.010270

Meystre, S., Kim, Y., Gobbel, G., Matheny, M., Redd, A., Bray, B., & Garvin, J. (2017). Congestive heart failure information extraction framework for automated treatement performance measures assessment. *Journal of the American Medical Informatics Association, 24*(e1), e40 - e46. https://doi.org/10.1093/jamia/ocw097

Moher, D., Liberati, Al, Tetzlaff, J., Altman, D., & The Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The Prisma Statement. *PloS Medicine, 6*(7). https://doi.org/10.1371/journal.pmed.1000097

Monsen, K. A. (2006). *History of Public Health Nurse Home Visiting* (Doctoral Dissertation).

Monsen, K. A. (2018a). *Intervention Effectiveness Research: Quality Improvement and Program Evaluation.* Springer International Publishing AG.

Monsen, K. A. (2018b). The Omaha System as an ontology and meta-model for nursing and healthcare in an era of Big Data [Editorial]. *ScienceDirect, 2,* 113-114. https://doi.org/10.1016.kontakt.2018.03.001

Monsen, K. A., Banerjee, A., & Das, P. (2010). Discovering client and intervention patterns in home visiting data. *Western Journal of Nursing Research, 32*(8), 1031-1054. https://doi.org/10.1177/0193945910370970

Monsen, K. A., Holland, D., Fung-Houger, P., & Vanderboom, C. (2014). Seeing the whole person: Feasibility of using the Omaha System to describe strengths of older adults with chronic illnesses. *Research and Theory for Nursing Practice: An International Journal, 28*(4), 299 – 315. https://doi.org/10.1891/1541-6577.28.4.299

Monsen, K. A., Maganti, S., Siaquinto, R., Mathiason, M., Bjarnadottir, R., & Kreitzer, M., (2018), Use of the Omaha System for ontology-based text mining to discover meaning within CaringBridge social media journals. *ScienceDirect, 20*(3), 227-233. https://doi.org/10.1016/j.kontakt.2018.3.002

Monsen, K. A., Martin, K.S., & Bowles, K.H. (2012). Omaha System partnership for knowledge discovery and healthcare quality. *Computers, Informatics, Nursing (CIN).* https://doi.org/10.1097/NCN.0b013e318245cf3e

Monsen, K. A., Radosevich, D.M., Johnson, S. C., Farri, O., Kerr, M. J., & Geppert, J. S. (2012). Benchmark attainment by maternal and child health clients across public health nursing agencies. *Public Health Nursing, 29*(1), 11-18. https://doi-org./10.1111/j.1525-1446.2011.00967.x

Munoz, M., Real, J., Del Val, J., Vinyoles, E., Mundet, X., Domingo, M., Enjuanes, C, & Verdu-Rotellar, J. (2015). Impact of the sustaine control of cardiovascular risk factors on the first episode heart failure: The relevant role of primary care. European Journal of General Practice. 21(4), 224-30. https://doi.org/10.3109/13814788.2015.1049154

National Cancer Institute, Division of Cancer Control and Population Sciences. (2019). NCI comorbidity index overview: History of the NCI Comorbidity Index. https://healthcaredelivery.cancer.gov/seermedicare/considerations/comorbidity.html

Nayak, A., Hicks, A., & Morris, A., (2020). Understanding the complexity of heart failure risk and treatment in black patients. *Circulation: Heart Failure, 13*(8), e007264. https://doi.org/1-.1161/CIRCHEARTFAILURE.120.007264

Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S. (2019). Dissecting racial bias in an algorithm used to manage the health of populations. *Science,* 366(6464), 447 - 453. https://doi.org/10.1126/science.aax2342

Omaha System. (n.d.). *Omaha System Overview*. https://www.omahasystem.org/overview

Ontotext.com – What are Ontologies? (2019). Retrieved August 1, 2021, https://www.ontotext.com/knowledgehub/fundamentals/what-are-ontologies/

Panahiazar, M., Taslimitehrani, Pereira, N., & Pathak, J. (2105). Using EHRs and machine learning for heart failure survival analysis. *Studies in Health Technology and Informatics, 216,* 40 - 44. PMID: 26262006 PMCID: PMC4905764

Polit, D. & Beck, C. (2014). *Essentials of nursing research, Appraising evidence for nursing practice* (8th edition). Wolters Kluwer Health | Lippincott Williams & Wilkins.

QualityNet (a division of CMS), (2019). Hospital Readmission Reduction Program (HRRP). https://ww.qualitynet.org/inpatient/hrrp

Radhakrishna, K., Bowles, K., & Zettek-Sumner, A. (2013). Contributors to frequent telehealth alerts including false alerts for patients with heart failure: a mixed methods exploration. Applied Clinical Informatics. 4(4), 465-75. https://doi.org/10.4338/ACI-2013-06-RA-0039

Shao, Y., Mohanty, A., Ahmed, A., Weir, C., Bray, B., Shah, R., Redd, D., & Zeng-Treitler, Q. (2016). Identification and use of frailty indicators from text to examine associations with clinical outcomes among patients with heart failure. AMIA - Annual Symposium Proceedings/AMIA Symposium, eCollection, 1110-1118. PMID: 28269908

Sideris, C., Alshurafa, N., Pourhomayoun, M., Shahmohammadi, F., Samy, L., & Sarrafzadeh, M. (2015). A data-drive feature extraction framework for predicting the severity of condition of congestive heart failure patients. *2015 37th Annual Conference proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. 2534-2537. https://doi.org/10.1109/EMBC.2015.7318908

Smets, M. Smeets, M., Van den Bulck, S., Janssens, S., Aertgeerts, B., & Vaes, B. (2018). Defining quality indicators for heart failure in general practice, ACTA Cardiologica. https://doi.org/10.1080.00015385.2018.1492659

Thompson, L., Bekelman, D., Allen, L, & Peterson, P. (2015). Patient-Reported outcomes in heart failure: existing measures and future uses. *Current Heart Failure Reports, 12,* 236-246. https://doi:.org/10.1007/s11897-015-0253-9

Tukey, J. (1977). *Exploratory Data Analysis*. Addison-Wesley Publishing Co.

University of Minnesota School of Nursing Omaha System Partnership, (2020). http://omahasystempartnership.org/

Waltz, C. F., Strickland, O. L., & Lenz, E. R. (2010). *Measurement in nursing and health research* 4th edition. Springer Publishing Company.

Walsh, M., Albert, N., Curtis, A., Gheorghiade, M., Heywood, J., Liu, Y., Mehra, M., O'Connor, C., Reynolds, D., Yancy, C., & Fonarow, G. (2012). Lack of association between electronic health record systems and improvement in use of evidence-based heart failure therapies in outpatient cardiology practices, *Clinical Cardiology*, *35*(3), 187-96, https://doi.org/10.1002/clc.21971

Werner, C., (2011). The Older Population – 2010 Census Briefs. Retrieved August 1, 2021, from https://www.census.gov/prod/cen2010/briefs/c2010br-09.pdf

Yancy, C., Jessup, M, Bozkurt, B., Butler, J., Casey, D., Drazner, M., Fonarow, G., Geraci, S., Horwich, T., Januzzi, J., Johnson, M., Kasper, E., Levy, W., Masoudi, F., McBride, P., McMurray, J., Mitchell, J., Peterson, P., Riegel, B., Sam, F., Stevenson, L., Tang., W., Tsai, E., & Wilkoff, B. (2013). 2013 ACCF/AHA guideline for the management of heart failure. *Circulation, 128*(16), e240 – e327. https://doi.org/10.1161/CIR.0b013e31829e8776

Yancy, C., Jessup, M., Bozkurt, B., Butler, J., Casey, D., Colvin, M., Drazner, M., Flippatos, G., Fonarow, G., Givertz, M., Hollenberg, S, Lindenfeld, J., Masoudi,

F., McBride, P., Peterson, P., Stevenson, L., & Westlake, C. (2017). 2017 ACC/AHA/HFSA focused update of the 2013 ACC/AHA/AHA guideline for the management of heart failure: A report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines and the Heart Failure Society of America. *Circulation*, *136*(6), e137-161, https://doi.org/10.1161/CIR.0000000000000509

Yee, D., Novak, E., Platts, A., Nassif, M., LaRue, S., & Vader, J. (2018). Comparison of the Kansas City Cardiomyopathy Questionnaire and Minnesota Living With Heart Failure Questionnaire in predicting heart failure outcomes. *American Journal of Cardiology*, *123*(5), 807 – 812, https://doi.org/10.1016/j.amjcard.2018.11.037

Zan, S., Agboola, S., Moore, S.A., Parks, K.A., Kvedar, J.C., & Jethwani, K. (2015) Patient engagement with a mobile web-baed telemonitoring system for heart failure self-management: A pilot study. JMIR mHealth uHealth, 3(2), e33. https://doi.org/10.2196/mhealth.3789