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Respiratory Vaccinations in Heart Failure Patient Population

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Respiratory Vaccinations in Heart Failure Patient Population

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in Nursing

by

Anna Dermenchyan

2023

ABSTRACT OF THE DISSERTATION

Respiratory Vaccinations in Heart Failure Patient Population

by

Anna Dermenchyan

Doctor of Philosophy in Nursing

University of California, Los Angeles, 2023

Professor Lynn V. Doering, Chair

Heart failure affects people of all ages and is the leading cause of death for both men and women in most racial and ethnic groups in the United States. Infections are one of the most common causes of hospitalization in heart failure, with respiratory infections as the most frequent diagnosis. Vaccinations provide the best protection against preventable respiratory infections. Despite being an easily accessible intervention, vaccines are underused in patients with heart failure. The purpose of this study was to determine rates of influenza, pneumococcal, and COVID-19 vaccination among a population of patients with heart failure (heart failure preserved ejection fraction [HFpEF], heart failure mid-range ejection fraction [HFmrEF], heart failure reduced ejection fraction [HFrEF], and heart failure unspecified ejection fraction [HFuEF]), identify patient factors associated with vaccination, and examine the association between provider type (primary care and cardiology) and vaccination status.

An observational study was conducted using data from an academic health system Heart Failure Registry from 2019 to 2022. The conceptual framework used to inform the study was the Chronic Care Model. The Heart Failure Registry contained adult patients (N=7341) with heart failure and data about their demographics, clinical and social characteristics, treatment background, and provider type. Descriptive statistics and frequencies were used to characterize the sample on all analytic variables. Chi square tests were used to compare sample differences by patient and provider factors and vaccination status. Multiple logistic regression models were estimated to examine the odds of vaccination among patients while adjusting for covariates.

Vaccination rates varied between influenza, pneumococcal, and COVID-19 vaccines. Of the three respiratory vaccines, 54.5% of patients had received an influenza vaccine, 74.7% had received a pneumococcal vaccine, and 81.3% had received a COVID-19 vaccine. Patients with preserved and mid-range heart failure had the highest vaccination levels in all three vaccine groups, while patients with reduced and unspecified heart failure had the lowest odds. Patients with a primary care provider, 65 years and older, Hispanic compared to White, accountable care organization member, or had managed care compared to commercial insurance, had higher odds of receiving all three vaccines. There is a need for individual providers and health systems to develop strategies to overcome heart failure vaccine disparities.

The dissertation of Anna Dermenchyan is approved.

Mary-Lynn Brecht

Kathleen Dracup

Anna F. Gawlinski

Jack Needleman

Lynn V. Doering, Committee Chair

University of California, Los Angeles

2023

Dedication

To my grandmother Mariam who exemplified hard work and perseverance. She suffered at the end of her life, going in and out of hospitals due to heart failure.

To my parents for their love and dedication to my success and well-being. They have always believed in me and all that I can accomplish.

To my sister and brother, who have encouraged me all my life and have been my go-to people.

To my soul sisters and sisterhood of cousins who ground me and provide support when I need them the most.

To my mentors who have given me their time, expertise, and support to contribute to my growth.

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To my colleagues in quality improvement, whose passion and dedication to improving healthcare drive me to be better every day.

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Table of Contents

List of Figures

List of Tables

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Chapter 1: Abstract, Research Question, and Specific Aims

Abstract

Heart disease remains the number one cause of death globally. The final common pathway for heart disease is heart failure, a serious condition where the heart does not pump adequately to meet the body's needs. It affects people of all ages and is the leading cause of death for both men and women in most racial and ethnic groups. In the United States, 6.2 million adults are diagnosed with heart failure. The disease is responsible for 3.3 million clinic visits each year, and it is the most common diagnosis in hospital patients 65 years and older. Despite the advances in medical knowledge, pharmacological therapies, and technology, heart failure continues to be a significant burden to the healthcare system.

Infections are the most common cause of hospitalization in heart failure, with respiratory infections as the most frequent diagnosis. Respiratory infections such as influenza, pneumonia, and COVID-19 make heart failure worse. Infection in the lungs can strain the heart, which can worsen heart failure and cause long-term complications for this patient population. Vaccinations provide the best protection against preventable respiratory infections. Multiple studies have shown the benefits of vaccination for the prevention and management of heart disease. Despite being an easily accessible intervention, vaccines are underused in patients with heart failure.

This research aims to study the vaccination rates of influenza, pneumococcal, and COVID-19 among a stratified heart failure patient population and compare vaccination status within patient and care team factors. The conceptual framework from the Chronic Care Model guides the research design. Data from a health system Heart Failure Registry (N=7341) will be used for cross-sectional analysis. Descriptive statistics, bivariate tests, and multiple logistic regression analysis will be conducted to study the relationship between independent variables

(patient and care team factors) on the dependent variable (vaccination status). Patient factors include heart failure category, demographics, socioeconomic status, and social vulnerability index. Care team factors include the four provider types: primary care provider, cardiology provider, both providers, and no primary care or cardiology provider registered in the health system. Vaccination status includes influenza, pneumococcal, and COVID-19 vaccines. The goal of this study is to identify strategies that can improve the equitable and optimal implementation of vaccines in ambulatory care practices.

Research Question

What patient and provider factors are associated with respiratory vaccination status among patients with heart failure that could lead to improvements in preventive care delivery?

Specific Aims

1. Examine whether there are differences in vaccination status for three recommended respiratory vaccines (influenza, pneumococcal, COVID-19) among patients with four types of heart failure (heart failure with preserved ejection fraction [HFpEF], heart failure with mid-range ejection fraction [HFmrEF], heart failure with reduced ejection fraction [HFrEF], heart failure unspecified ejection fraction [HFuEF]), controlling for patient and provider factors.

   Hypothesis: Patients in more severe heart failure categories will have higher levels of vaccination compared to patients with less severe heart failure, independent of patient and provider factors.

2. Explore what patient factors (heart failure category, gender, age, race/ethnicity, language, accountable care organization [ACO] status, insurance, social vulnerability index [SVI]) are

associated with vaccination status (influenza, pneumococcal, and COVID-19), controlling for provider factors.

Hypothesis: Patients with sociodemographic vulnerabilities will have lower levels of vaccination, independent of provider factors.

3. Investigate whether there is an association between provider type (primary care provider, cardiology provider, both providers, no primary care or cardiology provider registered in the health system) and patient vaccination status (influenza, pneumococcal, and COVID-19), controlling for patient factors.

   Hypothesis: Having a primary care provider compared to other provider types will positively correlate with vaccination status independent of patient factors.

Chapter 2: Literature Review

Introduction

Heart disease remains the number one cause of death globally. The final common pathway for heart disease is heart failure. In the United States (U.S.), 6.2 million adults are diagnosed with heart failure, with more than 670,000 dying annually [1-3]. It is a chronic condition with no cure. The prevalence of heart failure is projected to increase by 46%, with cost estimates of $69.7 billion annually by 2030 [4]. The majority of the financial cost is from rehospitalization within 30 days [2]. The low use of preventive care services like health screenings and vaccinations can add to the risk of poor outcomes such as disability and premature death. Despite the advances in medical knowledge, pharmacological therapies, and technology, heart failure continues to be a significant burden to the healthcare system due to the high rates of morbidity, mortality, and cost [5].

Infections are the most common cause of hospitalization in heart failure, with respiratory infections as the most frequent diagnosis [6, 7]. Infections can cause heart muscle damage and trigger acute coronary syndromes that worsen underlying heart conditions [6, 8]. Infection in the lungs due to influenza, pneumonia, and COVID-19 can strain the heart, which can worsen heart failure and cause long-term complications for this patient population. Vaccinations provide the best protection against preventable respiratory infections [9]. Multiple studies have shown the benefits of vaccination for the prevention and management of heart disease [4, 9-14]. Despite being an easily accessible intervention, vaccines are underused in patients with heart failure [9, 12].

Background

Heart failure affects people of all ages and is the leading cause of death for both men and women in most racial and ethnic groups [3, 15, 16]. It can significantly affect a person's quality of life. The disease is responsible for around 3.3 million clinic visits each year [3], and it is the most common diagnosis in hospital patients 65 years and older [3, 16]. Older adults have an increased likelihood of additional comorbidities, as well as an increased risk of hospitalization and mortality [17]. Greater than 50% of the patients diagnosed with heart failure die within five years of diagnosis [3, 4]. Over the past decade, death rates for adults between 35 and 64 have also risen. Data show that younger adults are experiencing disparities in heart failure care compared with older adults (≥65) [18]. Heart failure prevalence is projected to increase in the U.S. due to the aging population and the high rates of obesity and diabetes in the younger population [1, 3].

Heart failure is a complex and progressive clinical syndrome that results from structural and functional impairment of ventricular filling or contractility. A diagnosis is based on history, physical examination, and laboratory and imaging data. The left ventricular ejection fraction (LVEF), generally measured by echocardiography, remains the cornerstone of heart failure diagnosis, characterization, and treatment selection. A normal LVEF may be between 50 and 70 percent. Heart failure with LVEF ≥50 percent is heart failure with preserved ejection fraction (HFpEF). This type of heart failure is also known as diastolic failure/dysfunction since the left ventricle loses its ability to relax normally because the muscle has become stiff. Heart failure with LVEF ≤40 percent is known as heart failure with reduced ejection fraction (HFrEF). This type of heart failure is also known as systolic failure/dysfunction since the left ventricle loses its ability to contract normally. If there is a combination of diastolic and systolic dysfunction, it is considered HFrEF. Heart failure with LVEF of 41 to 49 percent is heart failure with mid-range ejection fraction (HFmrEF), also known as borderline ejection fraction (HFbEF). This category was previously treated as HFpEF. However, clinical characteristics often resemble HFrEF more than HFpEF [19]. When a specific diagnosis has not been established to determine preserved, reduced, or mid-range ejection fraction, a general heart failure unspecified ejection fraction (HFuEF) diagnosis is used to capture the condition. These terms are further defined in Table 2.1.

The differentiation of heart failure classification is essential for the clinical management of the disease and effective therapies. Guideline-directed medical therapy (GDMT) has been demonstrated to reduce hospitalizations and prolong survival for patients with HFrEF [20, 21]. However, HFpEF is a much more complex syndrome in which co-morbidities, such as chronic obstructive pulmonary disease, depression, anemia, diabetes, and coronary artery disease, play a significant role in decompensation episodes [20]. Clinical trials of pharmacologic therapy for HFpEF have mainly produced neutral results. Some subgroup and post hoc analyses suggest that some treatments for HFrEF might also be effective in HFmrEF [19]. The management of patients with HFpEF is primarily directed toward treating associated conditions [20]. Identifying the diastolic, systolic, and mid-range nature of heart failure is critical for clinical management. An accurate diagnosis and documentation are necessary to capture the patient's severity of illness and make treatment recommendations. Therefore, there is a push to specify the HFuEF to a more specific diagnosis to apply appropriate treatments.

Patients with heart failure are at higher risk of severe problems from respiratory illnesses [6, 8]. Influenza, pneumonia, and COVID-19 infections can trigger arrhythmias, acute coronary syndromes, and exacerbate underlying heart conditions [22]. Vaccinations provide the best protection against preventable respiratory infections [9]. Bhatt and colleagues (2018) evaluated

313761 patients hospitalized at centers participating in the Get with The Guidelines-Heart Failure (GWTG-HF) registry from October 2012 to March 2017 [10]. Nearly 1 in 3 patients hospitalized with heart failure were not vaccinated for influenza or pneumococcal, and vaccination rates did not improve from 2012 to 2017. The hospitals that exhibited higher vaccination rates performed well in other heart failure quality of care measures [4, 10].

Guideline-recommended therapies are vital in improving outcomes and preventing recurrent cardiovascular events [20, 21]. Heart failure guidelines from the American Heart Association and American College of Cardiology Foundation (AHA/ACCF), Heart Failure Society of America (HFSA), and European Society of Cardiology (ESC) do not cover vaccination recommendations in detail. The U.S. Preventive Services Task Force (USPSTF) and Advisory Committee on Immunization Practices (ACIP) remain vague on specific vaccine recommendations but make general recommendations for chronic heart, lung, liver, diabetes, and smoking. Nonetheless, there is consensus in the science community to provide influenza, pneumococcal, and COVID-19 vaccines to all patients in the absence of contraindications.

Evidence-based approaches, such as the frequency of touchpoints with providers and optimization of evidence-based guidelines, have been shown to improve outcomes and decrease mortality in patients [5, 20]. Primary care and cardiology providers have varying practice trends in managing patients with heart failure through performing preventive care measures and guideline-recommended therapies [5, 23, 24]. Stable heart failure patients are managed mainly by primary care providers. In some cases, guideline-recommended medications might be underused and not optimized. In comparison, most cardiologists receive heart failure patients upon discharge after inpatient admissions in an academic health center. The focus of care after hospitalization is medication titration and optimization of treatment outcomes. It is unknown to what extent individuals with heart failure receive their preventive care from cardiology providers. There is a need to optimize team-based care for heart failure patients by improving co-management practices between primary care and cardiology providers and their care teams.

The primary aim of the literature review was to understand the current research on respiratory vaccinations in heart failure management, including influenza, pneumococcal, and COVID-19. The summary of findings highlights the analysis and identifies what is known and unknown within this area of research. The discussion explores what is known about preventative care delivery regarding vaccinations among primary care and cardiology providers. The overall goal of this literature appraisal was to understand what strategies have improved the equitable and optimal implementation of vaccine delivery in ambulatory care practices.

Methods

The literature review evaluated current publications that included systematic reviews, integrative reviews, meta-analyses, randomized control trials (RCTs), non-randomized studies, quantitative descriptive studies, mixed-methods studies, and qualitative research that address the relevant topic of respiratory vaccinations in heart failure patient population. To identify applicable studies, a search was conducted in PubMed and Google Scholar databases to identify relevant original research and review articles from January 1, 2000, to the present. Particular focus was paid to research publications in the last five years.

The search strategy were a combination of Medical Subject Headings (MeSH) terms and key words that encompassed heart failure, respiratory infections, respiratory vaccinations, influenza vaccine, pneumococcal vaccine, COVID-19 vaccine, primary care management of heart failure, cardiology management of heart failure, health screening, ambulatory care, and disease management. The titles and abstracts from these searches were reviewed, full-text articles were obtained for relevant manuscripts, and reference lists were reviewed to identify additional manuscripts appropriate for review. In the end, 32 publications met the criteria and were included in the targeted review. All citations and manuscripts, including background articles, were imported into an EndNote X9 database.

Results

Respiratory infections were the third leading cause of hospitalization in heart failure [6, 9]. Bacterial and viral infections could cause decompensation and deterioration of the heart muscle [25]. In a seminal study, Alon et al. (2013) demonstrated that among 9335 patients with heart failure, 3530 (38%) were hospitalized at least once due to infections [6]. The top three diagnoses for hospital admissions were respiratory infection (52.6%), sepsis/bacteremia (23.6%), and urinary infections (15.7%). Compared to other indications, hospitalizations due to infections were associated with increased 30-day mortality (13% vs. 8%, $p<0.0001$). Compared to those without heart failure, patients with heart failure had an almost 50% increase in infection-related admissions and a 62% increase in the 30-day mortality [6].

Vaccines are available to prevent a number of respiratory diseases and reduce the incidence and severity of disease. Vaccine recommendations are based on age, health conditions, job, lifestyle, or travel habits. The Centers for Disease Control and Prevention (CDC) recommend influenza, pneumococcal, and COVID-19 vaccines for adults with heart disease (Table 2.2). The influenza vaccine protects against the seasonal flu. The pneumococcal vaccine protects against serious pneumococcal infections. COVID-19 vaccine protects against serious illness when infected with COVID-19. Adverse reactions to vaccinations are rare and happen within a few hours of being given the vaccine. There are protocols and procedures for treating adverse reactions quickly and effectively. Vaccinations can provide cardioprotection through a pathophysiological mechanism to induce antibody production and reduce chronic inflammation in the heart [4, 9, 26].

Influenza Vaccine

Among adults hospitalized with flu during the winter season, heart disease was one of the most common chronic conditions [12, 27]. About half of adults hospitalized with influenza had heart disease. Influenza was associated with an increase in heart attacks and stroke [27]. A recent study found that heart attacks were six times higher within a week of confirmed influenza infection [28]. These findings were most pronounced for older adults and those experiencing their first heart attack. In 2013, Udell et al. published a meta-analysis of five RTCs, including 3238 influenza vaccinated patients and 3231 unvaccinated patients [29]. Influenza vaccinated patients had a lower risk for a composite of major cardiovascular events (2.9% vs. 4.7%; relative risk [RR] 0.64, 95% confidence interval [CI] 0.48–0.86, p = 0.003). The effect of vaccination was greater in patients with higher-risk coronary disease [29].

Data from the PARADIGM-HF trial (2016) demonstrated that from 8099, only a small percentage of patients with heart failure (N=1769, 21%) received the influenza vaccine. Vaccinations were associated with a reduced risk of all-cause mortality in a cohort of patients with reduced LVEF (hazard ratio [HR] 0.81; 95% CI 0.67 to 0.97, p = 0.015) [13]. The GWTG–HF registry data (2018) showed that 68% (N=121317) received influenza vaccination. In a subset of 64614 patients, the one-year all-cause mortality rates in vaccinated patients were similar to unvaccinated patients (adjusted HR 0.96, 95% CI 0.89 to 1.03, p = 0.25) [10]. However, more than 50% of the patients were excluded from the analysis due to missing data, which can bias these results.

Modin et al. (2019) performed a cohort study including all patients with heart failure 18 years of age or older (N=134048) in Denmark [30]. The vaccination coverage ranged from 16% to 54%. After adjustment for comorbidities, medications, household income, and education level, receiving one vaccination dose was associated with an 18% reduced risk of death (all-cause: HR 0.82; 95% CI 0.81–0.84, p<0.001; cardiovascular causes: HR 0.82, 95% CI 0.81–0.84, p<0.001). A greater cumulative number of vaccinations were associated with more significant reductions in the risk of death than intermittent vaccination [30].

Gotsman et al. (2020) evaluated influenza vaccination status during the winter season of 2017/2018 and its association with cardiac-related hospitalizations and mortality one year after vaccination in Israel [31]. Out of 6435 patients with heart failure, 4440 (69%) were vaccinated. Patients vaccinated were older patients with more co-morbidities. Vaccination was associated with reduced mortality (HR 0.77, 95% CI 0.65 to 0.91, p <0.01) as well as reduced death and cardiovascular hospitalizations (HR 0.83 95% CI 0.76 to 0.90, p <0.001). A propensity score matched control analysis demonstrated that vaccination was associated with improved survival (HR 0.80, 95% CI, 0.67 to 0.95, p <0.01) and reduced mortality and cardiovascular hospitalizations (HR 0.86, 95% CI 0.79 to 0.94, p <0.001). Influenza vaccination was associated with improved clinical outcomes [31].

Influenza vaccine literature demonstrated that most studies were retrospective, observational, and trial sub-analyses [4, 32]. The cohort studies on the efficacy of the influenza vaccine in patients with heart failure reported some conflicting results. The best evidence available was from observational cohort studies showing influenza vaccination was associated with a lower risk of poor outcomes and mortality in patients with heart failure [12, 33, 34], during influenza and non-influenza season [33]. Implementation of influenza vaccination recommendations against respiratory infections remains suboptimal [9]. A randomized placebo-controlled trial (Clinicaltrials.gov, NCT02762851) is currently being conducted on influenza vaccine outcomes [35].

Pneumococcal Vaccine

Pneumococcal pneumonia infections were one of the leading causes of heart failure admissions to hospitals [36, 37]. The pneumococcal disease puts older adults at the greatest risk of severe illness and death. Lamontagne et al. (2008) evaluated 20000 inpatients at high risk for coronary events. Patients who had received the pneumococcal vaccination two years before hospital admission had significantly lower rates of myocardial infarction [38]. Two population-based studies from Denmark (2008 & 2013) showed increased 30-day mortality from pneumonia for patients with heart failure compared to non-heart failure (24.4% vs. 14.4%) [36, 37]. However, they did not have information on vaccination status. In the Cardiovascular Health Study (CHS), 5290 community-dwelling adults with no diagnosis of heart failure, 65 years and older, were followed for 13 years. The lack of pneumococcal vaccination was associated with a higher relative risk of heart failure (aHR, 1.37, 95% CI 1.01–1.85, p=0.044) [39].

Mara et al. (2020) conducted a meta-analysis of 18 studies with 716108 participants to evaluate the protective effect of 23-valent polysaccharide pneumococcal vaccination (PPV23) in the general adult population for any cardiovascular event [40]. Vaccination was associated with a decreased risk of cardiovascular events (RR 0.91, 95% CI 0.84–0.99) and myocardial infarction (RR 0.88, 95% CI 0.79–0.98) in all age groups. The effect was significant in patients younger than 65. PPV23 vaccine was also associated with a substantial reduction in the risk of all-cause mortality in all age groups (RR 0.78; 95% CI 0.68–0.88) [40].

Marques Antunes et al. (2021) also conducted a meta-analysis of five studies with 163756 participants that evaluated the protective effect of PPSV23 and/or PCV13 on all-cause mortality in adults with a history of cardiovascular disease or at very high risk for cardiovascular disease [41]. Only observational studies were included since there were no RTCs. A significant decrease in all-cause mortality was found (HR 0.78, 95% CI 0.73–0.83) [41]. In the GWTG–HF registry, the efficacy of the pneumococcal vaccination was assessed in 256460 [10]. Of the total, 66% received pneumococcal vaccination. In a subset of 64614 patients, vaccinated and unvaccinated patients had similar 1-year all-cause mortality rates (adjusted HR 0.95, 95% CI 0.89–1.01) [10].

Like influenza, but less studied in heart failure, the pneumococcal vaccine literature was primarily retrospective, observational, and trial sub-analyses [9]. These studies demonstrated variability in findings and conflicting results. However, with a closer look, some analyses excluded many of the patient population due to missing data. One study had a low confidence interval, which could mean some bias. Overall, the pneumococcal vaccine showed improved outcomes in patients with heart failure, especially those 65 years and older.

COVID-19 Vaccine

Infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) could directly or indirectly lead to myocardial injury [42, 43]. Individuals with a pre-existing heart condition who developed COVID-19 had worse outcomes than those without heart disease [42]. Underlying heart disease was associated with an increased risk of up to 10.5% of in-hospital death among patients hospitalized with COVID-19 [44]. Even in individuals without pre-existing cardiac conditions, COVID-19 could also manifest with an acute cardiovascular syndrome [22]. Older adults and people with severe underlying medical conditions like heart failure were at a higher risk of developing serious complications from COVID-19 illness. With the ongoing COVID-19 pandemic, there was a potential threat of a concurrent epidemic with influenza [34].

In a study of 6439 patients hospitalized with COVID-19 in New York City, patients with chronic heart failure required assisted ventilation more often (3.6 times more) and had a higher risk of death (1.9 times more) [45]. A large retrospective study performed in the U.S. found that patients with acute heart failure hospitalized with COVID-19 were at high risk for complications, and 24.2% of them died during hospitalization (compared with 2.6% for patients hospitalized with acute heart failure without COVID-19) [46]. In another study, patients with a history of chronic heart failure developed acute heart failure more frequently when infected with SARS-CoV-2 (11.2% vs. 2.1%) and had significantly higher mortality rates (48.7% vs. 19.0%) [47].

At the time of the literature search, there were no published data on the protective effect of the COVID-19 vaccine in patients with heart failure in terms of hospitalization or mortality outcomes. Also, Clinicaltrials.gov did not have any studies listed on COVID vaccinations on heart failure outcomes. The CDC recommends that patients with heart failure be considered high risk and prioritized for vaccination. Vaccination remains the most promising global approach for controlling the pandemic.

Discussion

Vaccinations in Heart Failure Management

Preventive and health screenings are considered the responsibility of primary care providers. Despite numerous national, state, and local campaigns aimed at improving vaccination and preventative screening rates, the rate of vaccinations remains low. There is much public fear about vaccinations causing illness or actual disease. Vaccination uptake is low among patients younger than 65, non-Hispanic Black individuals, those without health insurance, and those with diminished access to healthcare services [26]. Behavioral factors such as perceived vaccine efficacy, vaccine safety, and attitudes towards vaccination play an important role in vaccine acceptance at the individual and community levels [26]. The COVID-19 pandemic could have changed perceptions about the role of vaccinations in safeguarding health. Opportunities exist for all health care providers that manage the care of heart failure patients to inquire and provide influenza, pneumococcal, and COVID-19 vaccines.

The care for the vast majority of U.S. patients with heart failure remains in the hands of primary care providers [24]. In a longitudinal observational study by Prado-Galbarro et al. (2019), 1058 patients with heart failure managed by primary care providers showed a five-year survival of 65% if there was no hospitalization vs. 53% if hospitalized at least once [48]. Factors with protective effects were when the patient had received the annual influenza vaccine (HR = 0.04; 0.01-0.15) and having an X-ray ordered by the provider (HR = 0.76; 0.67-0.88). These findings indicated that hospitalizations were associated with a significant increase in mortality in patients diagnosed with heart failure [48]. Primary care provider follow-up affects patient outcomes.

In the current environment, we do not have enough cardiology providers or heart failure specialists to manage a population of 6.2 million adults with heart failure. Therefore, primary care providers are left with most of the responsibility. A primary care provider is a health care professional who practices general medicine. Most are physicians, but nurse practitioners and physician assistants also manage heart failure patients. Generally, primary care is the first stop for medical care. Regular primary care visits can help patients build provider and care team relationships, which can help diagnose heart failure early and counsel patients based on risk factors for cardiovascular disease [5, 24].

A large percentage of patients believe their cardiology provider can manage their primary care needs [23]. In most cases, cardiology providers deal with cardiac problems and usually do not deliver preventative vaccinations or screenings. The specialists typically focus on their domain and do not act in the role of the primary care provider. Edwards et al. (2014) showed a 12-year declining trend, from 28% to 8% (2000-2012), where specialists identified as patients' primary care providers. The study results also demonstrated that the quality of care for cardiovascular disease was better in visits to cardiologists than in primary care providers but was similar or better in visits to primary care providers compared to visits to other medical specialists [23].

Team-based care is a cornerstone of the chronic care model and patient-centered medical home. Population health management uses a team-based approach to improve the coordination of care. Literature shows that utilizing a team to manage heart failure can improve the quality of care and outcomes for patients with heart failure [49-51]. Interdisciplinary teams can be organized to care for patients in both the inpatient and outpatient settings. In addition to primary care and cardiology providers, the team can include registered nurses, dieticians, pharmacists, social workers, physical therapists, and psychologists. Patients themselves, as well as their families and caregivers, are an integral part of the team. Since heart failure tends to be one of the most challenging diseases to manage, there are a lot of financial incentives to cut costs and improve the quality of care. Care teams can be evaluated based on their ability to improve morbidity and mortality, decrease rehospitalizations, cut costs, and provide patient, caregiver, and provider satisfaction [52].

Role of Nursing

Registered nurses (RNs) are in an ideal position to identify patients who need screening and vaccinations. RNs are often included as part of the team and are responsible for a diverse range of interventions. Nursing interventions have been extensively studied and have been shown to positively impact the care of patients with heart failure [53]. Close follow-up by an RN in the outpatient setting has been shown to improve patient self-care, reduce readmissions, shorten the length of stay, and reduce costs [52]. Furthermore, when the nurse-led intervention starts during hospitalization and provides assistance with the transition of care to the outpatient setting, there is an additional benefit of improved quality of life [52-54]. More RNs are needed in primary care settings to address social determinants of health and care for patients as part of interprofessional teams [54]. Primary care organizations can start to integrate and expand the role of RNs in their current practice.

The RN's role in the vaccination process includes assessment, communication, administrative safety, and follow-up. RNs determine what recommended vaccines are needed based on the patient's immunization history. They can educate patients on the efficacy and safety of the vaccine and help answer questions to fill in knowledge gaps. RNs take medical histories and ask about allergies to ensure a safe vaccination process. They provide the safe handling, storage, and administration of vaccinations. RNs are also accountable for post-vaccination monitoring, including recognizing and managing any physical or emotional reactions to vaccines. The role of an RN is key in providing medical care to patients with underlying health conditions, collating vaccination data, and taking patient records.

Gaps in the Literature

The primary aim of the literature review was to understand the current research on respiratory vaccinations in heart failure management. Results showed some variability with vaccinations and heart failure outcomes. Large multicenter RCTs are needed to evaluate the efficacy of influenza, pneumococcal, and COVID-19 vaccinations in preventing cardiovascular events in patients with heart failure. However, there is enough evidence to support vaccine recommendations for all patients with heart failure, regardless of the heart failure category. Future trials should enroll a broader study population, including all types of heart failure.

Furthermore, research is needed to understand vaccination rates between different demographic groups such as race, gender, and socioeconomic status. To design an equitable and optimal care delivery system, there needs to be a team-based approach with targeted population preventative care delivery. Further evidence-based healthcare performance measures are needed that reflect improved clinical outcomes in patients with heart failure.

Conclusion

Heart failure is associated with considerable morbidity, mortality, and cost. Respiratory infections cause significant disease and poor outcomes in patients with heart failure. Influenza, pneumococcal, and COVID-19 vaccines can help protect the cardiac muscle and reduce the incidence of respiratory infections. Multiple studies have shown the benefits of vaccination for preventing and managing heart disease. Despite being an easily accessible intervention, vaccinations are underutilized as an essential tool for preventing poor outcomes in patients with heart failure. A team-based multipronged approach is needed to improve vaccination rates and the care for patients with heart failure. Further understanding of current preventive practices can help guide population-level interventions to improve vaccination rates.

Table 2.1. Key Terms and Definitions

Term	Definition
Vaccine	A preparation that is used to stimulate the body's immune response against diseases. Vaccines are usually administered through needle injections, but some can be administered by mouth or sprayed into the nose.
Vaccination	The act of introducing a vaccine into the body to produce protection from a specific disease.
Immunization	A process by which a person becomes protected against a disease through vaccination. This term is often used interchangeably with vaccination or inoculation.
Cardioprotection	All mechanisms and means that contribute to the preservation of the heart or coronary arteries by reducing or preventing myocardial damage from injury, disease, or malfunction.
HFpEF	Heart failure with LVEF $\geq$ 50 percent is heart failure with preserved ejection fraction (HFpEF). This type of heart failure is also known as diastolic failure or dysfunction since the left ventricle loses its ability to relax normally during the resting period due to the heart muscle becoming stiff.
HFrEF	Heart failure with LVEF $\leq$40 percent is known as heart failure with reduced ejection fraction (HFrEF). In systolic or combined systolic/diastolic failure or dysfunction, the left ventricle loses its ability to contract normally and can't pump with enough force to push sufficient blood into circulation.
HFmrEF	Heart failure with LVEF of 41 to 49 percent is heart failure with mid-range ejection fraction (HFmrEF), also known as borderline ejection fraction (HFbEF). This category was previously treated as HFpEF. However, clinical characteristics often resemble HFrEF more than HFpEF.
HFuEF	When a specific diagnosis has not been established to determine preserved, reduced, or mid-range ejection fraction, a general heart failure unspecified ejection fraction (HFuEF) diagnosis is used to capture the condition.
Care Team	Clinical and administrative members who collectively take responsibility for a panel or population of patients. Care teams blend interdisciplinary skills, focusing on several people's insights to manage patient care.
Team-based Care	A delivery model where patient care needs are addressed as coordinated efforts among multiple health care providers and across settings of care.

Table 2.2. Respiratory Vaccine Schedule

The recommendations are summarized here using the chart from the Centers for Disease Control and Prevention, accessible on https://www.cdc.gov/vaccines/schedules/.

Vaccine	19-26 years	27-49 years	50-64 years	≥65 years
Influenza inactivated (IIV4) or Influenza recombinant (RIV4)	1 dose annually			
or **Influenza live attenuated (LAIV4)**	or 1 dose annually			
Pneumococcal (PCV15, PCV20, PPSV23)	1 dose PCV15 followed by PPSV23 OR 1 dose PCV20			1 dose PCV15 followed by PPSV23 OR 1 dose PCV20
COVID-19 (Pfizer-BioNTech, Moderna, Janssen/J&J)	2 doses of mRNA + Booster 1 dose of J&M + Booster *Additional doses for Moderately or Severely Immunocompromised			

Chapter 3. Conceptual Framework

Background

Heart disease is one of the major chronic diseases and the leading cause of death and disability in the U.S. The last stage of heart disease is heart failure. Heart failure trajectory is characterized by an overall gradual decline in function punctuated by periods of symptom exacerbation. Despite continuous improvements in pharmacological and non-pharmacological treatments, the clinical outcome of patients with heart failure remains poor, with an overall average of 52% mortality at five years [3]. This population requires ongoing care management using evidence-based therapies and a team-based approach to providing comprehensive and coordinated care.

Introduction

The Chronic Care Model (CCM) provides a framework and approach to caring for people with chronic diseases such as heart failure [55-58]. The CCM was initially developed in 1992 by a group of researchers at the MacColl Center for Health Care Innovation in Seattle to advance efforts in quality improvement research and improve outcomes in practice environments [58, 59]. The MacColl Institute developed the original CCM diagram (Figure 3.1) in 1998 to summarize the essential elements for improving chronic illness care at the following levels: community, health systems, practice team, and patient. The model depicts different areas of interaction that could lead to improved outcomes at the individual or population levels. The model has been adopted widely throughout Northern America and Europe [59].

The CCM has a broad range in the areas of chronic disease management, patient-centered care, population health, and value-based health care. The model synthesizes the best available evidence to guide chronic disease management through quality improvement efforts [49]. The model is dynamic and adaptable to new and better evidence as it becomes available. Healthcare services are provided to individuals or populations based on evidence and collaboration among the community and health system [57]. The concepts in the model are bundled together to drive the care team-patient relationship and impact patient outcomes.

There are four concepts under health systems: Self-Management Support, Delivery System Design, Decision Support, and Clinical Information Systems [59]. First, self-management support empowers and prepares patients to manage their health care. Effective self-management has multiple components, such as engagement in activities that promote health and wellbeing, interaction with health care providers who provide evidence-based care, patients making appropriate decisions for self-care, and patients managing the impact of the illness on oneself and family members [56]. Emphasis is placed on the patient’s role in managing their health, using important strategies to engage patients in goal-setting and problem-solving, and ongoing support and referrals from the internal and external community [56]. Since disease control and outcomes depend on the effectiveness of patients self-managing their disease, health systems need to create an environment of collaboration with patients and work together to define the specific problems, establish mutual goals, and create treatment plans that will increase self-management [49, 58].

Second, system design focuses on the delivery of effective and efficient clinical care [56]. Care team roles are clearly defined in this area, and tasks are distributed fairly among members within their scope of practice. Regular, proactive planned visits which incorporate patient goals help individuals maintain optimal health and allow health systems to better manage their resources. Visits often employ the skills of several team members. Case management support is provided to patients who have complex health care needs to receive additional coordination of services and adequate follow-up in a timely manner. The health system supports evidence-based care practice and culturally competent communication for patient interaction and engagement [56, 58].

Third, health systems decision support promotes clinical care that is consistent with scientific evidence and patient preferences [56, 58]. Clinicians have convenient access to the latest evidence-based guidelines for care for each chronic condition. Evidence-based guidelines are used in the daily clinical practice environment and with each patient to increase adherence to the medical recommendations. The guidelines are updated based on the latest research and made visible throughout the organization. Continual educational outreach to clinicians reinforces the utilization of these standards. In addition, motivational interviewing and teach-back methods are incorporated to engage patients [56].

Fourth, clinical information systems are about the accessibility of patient and population data to facilitate an efficient care delivery [56, 58]. Health systems harness technology to provide clinicians with a patient registry for given chronic diseases. A registry provides the information necessary to monitor patient health status and reduce complications. When accurate data are available to the healthcare providers and patients, decisions can be made based on evidence and outcomes. Data can facilitate individual patient goal setting and care planning. It can also identify quality and patient safety gaps that the organization can use for process improvement. Having robust clinical information systems allows patients to access their data through the patient portal, which can increase patients' confidence and skill in managing their health problems [60].

The second half of the CCM focuses on the bidirectional relationship between the "informed, activated patient" and "prepared, proactive practice team" [49]. The patient has a central role in managing their health. The practice team utilizes various community and health system tools and resources to inform and engage patients. In interaction with their practice team, the patient uses effective self-management support strategies like goal setting, action planning, problem-solving, and follow-up to manage their health and improve outcomes [59]. In this model, patients are expected to set goals, identify barriers and challenges, and monitor their conditions.

In summary, the CCM model offers a structure that can guide the community, health systems, practice teams, and patients regarding approaches to chronic disease management. The model is based on interventions that have worked for chronic illness care demonstrated in the literature. The model is aimed at patient-centered care to transform the way health care is delivered in a comprehensive and coordinated effort. The CCM is a commonly accepted approach by the primary care community as a Patient-Centered Medical Home (PCMH) model. It is widely used by health care organizations and national organizations like The Robert Wood Johnson Foundation. The group that developed the model hypothesized that if all model components are actively present in a system, it will drive improved outcomes. Since its publication, the model has been adopted for various communities and populations [59, 61].

Results

The CCM literature on heart failure management showed variation in the definitions of chronic care management and implemented interventions (i.e., hospital, clinic, home-based; team member involvement; frequency of visits; homogeneity of the population) [49, 61-65]. The majority of the studies focused on primary care settings, with a limited number aimed at specialty care. Very few studies included all components of the CCM, which made it challenging to investigate the relative contributions of each element [61]. Furthermore, since adequate control groups were lacking, it was difficult to assess if all components were required to improve outcomes. The common focus areas for outcome measures included hospital admissions, hospital readmissions, and mortality. None of the investigators looked at vaccination status within the CCM framework.

CCM Literature on Heart Failure Management

An earlier meta-regression analysis on heart failure was conducted to study CCM literature that focused on quality, length of follow-up, and a number of model components [64]. Fifteen systematic reviews and 46 primary studies (reported in 47 papers) were included in the analysis. Results show CCM reduced mortality by a mean of 18 percent (95% Confidence Interval [CI]: 0.72–0.94) and hospitalization by a mean of 18% (95%t CI: 0.76–0.93) and improved the quality of life by 7.14 points (95% CI: -9.55 to -4.72). However, considerable differences existed in hospitalization outcomes and quality of life scores across the studies [64].

Researchers from Italy investigated the impact of a CCM-based healthcare program on 1761 patients with heart failure treated by primary care general practitioners and nurses [62, 63]. The study subjects were matched to controls (N=3522) with a 1:2 ratio on multiple demographic and clinical characteristics. The interventions included planned follow-up visits, individualized counseling to optimize lifestyle modifications, and adherence to appropriate diagnostic and therapeutic pathways. Over a 4-year follow-up in the CCM group, a higher hospitalization rate was found (12.1 vs. 10.3 events/100 patient-years; incidence rate ratio [IRR] 1.15, $p=0.0030$), whereas mortality was lower (10.8 vs. 12.6 events/100 patient-years; IRR 0.82, $p<0.0001$). The CCM status was independently associated with a 34% increase in the risk of hospitalization and an 18% reduction in the risk of death ($p<0.0001$). The CCM status was associated with a 50% increase in planned heart failure hospitalizations, whereas the rate of 1-month readmissions showed no differences [62, 63]. Consistent provider follow-up increased patient monitoring and utilization of hospital services for care management.

A recent systematic review was conducted to assess the benefits and limitations of implementing CCM in primary care programs [65]. A total of 25 eligible articles that focused on programs targeting diabetes mellitus, hypertension, and cardiovascular disease were included. The majority of the enrolled programs (19/25) were led by professional healthcare providers such as physicians, physician/medical assistants, residents, primary care clinicians, registered nurses, nurse assistants, and health workers in at least one hospital or primary care center. Different types of intervention-related studies were used to investigate the impact of CCM implementation. The follow-up period varied between 3 months and 4 years. Most studies reported outcome improvements and patient compliance with treatment. For example, data from intervention groups showed an average of 15% improvement in the rate of measuring HbA1c, blood pressure, and blood lipids. Some studies demonstrated a reduction of the medical burden, such as healthcare utilization [65]. The authors concluded that CCM is effective in reducing the risk of heart failure and other cardiovascular diseases.

Discussion

The focus of the CCM is community and health system structures. Together, these structures support the practice team and patient interaction to drive improved outcomes. While this study discusses these factors, it does not include measures from the community and health system structure. Specifically, this research focuses on the patient and practice team interactions that drive vaccination outcomes. Patient measures include heart failure category, demographics, socioeconomic status, social vulnerability index, and proactive care risk. The practice team measures include the presence of primary care provider, cardiology provider, both providers, and no primary care or cardiology registered in the health system. The respiratory vaccine outcomes under study include influenza, pneumococcal, and COVID-19.

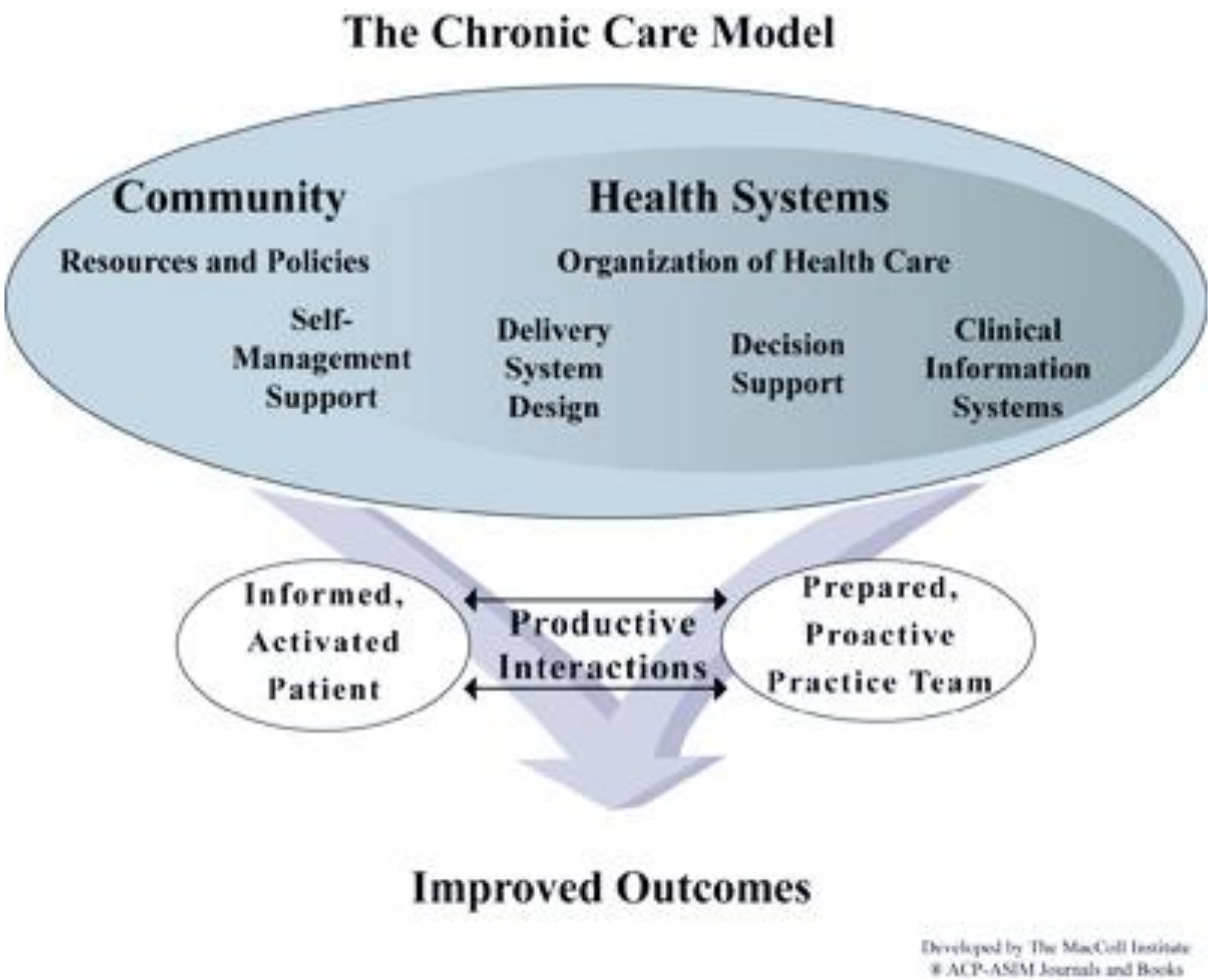
Analyzing heart failure category differences in vaccination status will identify best practices in specific areas that can be adopted system wide. Investigating the relationship between patient and care team factors can lead to understanding vaccination practices for influenza, pneumococcal, and COVID-19. The working hypothesis is that presence of a patient/provider relationship will positively correlate with vaccination status. Additionally, studying the combined effect of having a primary care provider versus other types of providers will give insights into interactions impacting outcomes. Further, analyzing vaccination rates between primary care and cardiology providers will provide insight into current ambulatory practices in preventive care delivery. Patient factors that can mediate or moderate vaccination status independent of provider status may include heart failure category, patient demographics and socioeconomic status, social vulnerability index, and proactive risk score.

The study findings from this research can identify areas of improvement and inform health system design (Figure 3.2). In self-management support, findings may support the development of policies and procedures to strengthen the patient and provider relationships based on the frequency of recommended interactions. In delivery system design, findings may support adjustment of evidence-based practice and guideline-recommended therapies in clinic workflows. In decision support, additional processes may be warranted for using electronic health record tools such as best practice alerts, SmartSets, and Health Maintenance. Finally, in the clinical information system, findings may support the use of the electronic health record to develop registries and dashboards, which increase data transparency and care gaps.

Conclusion

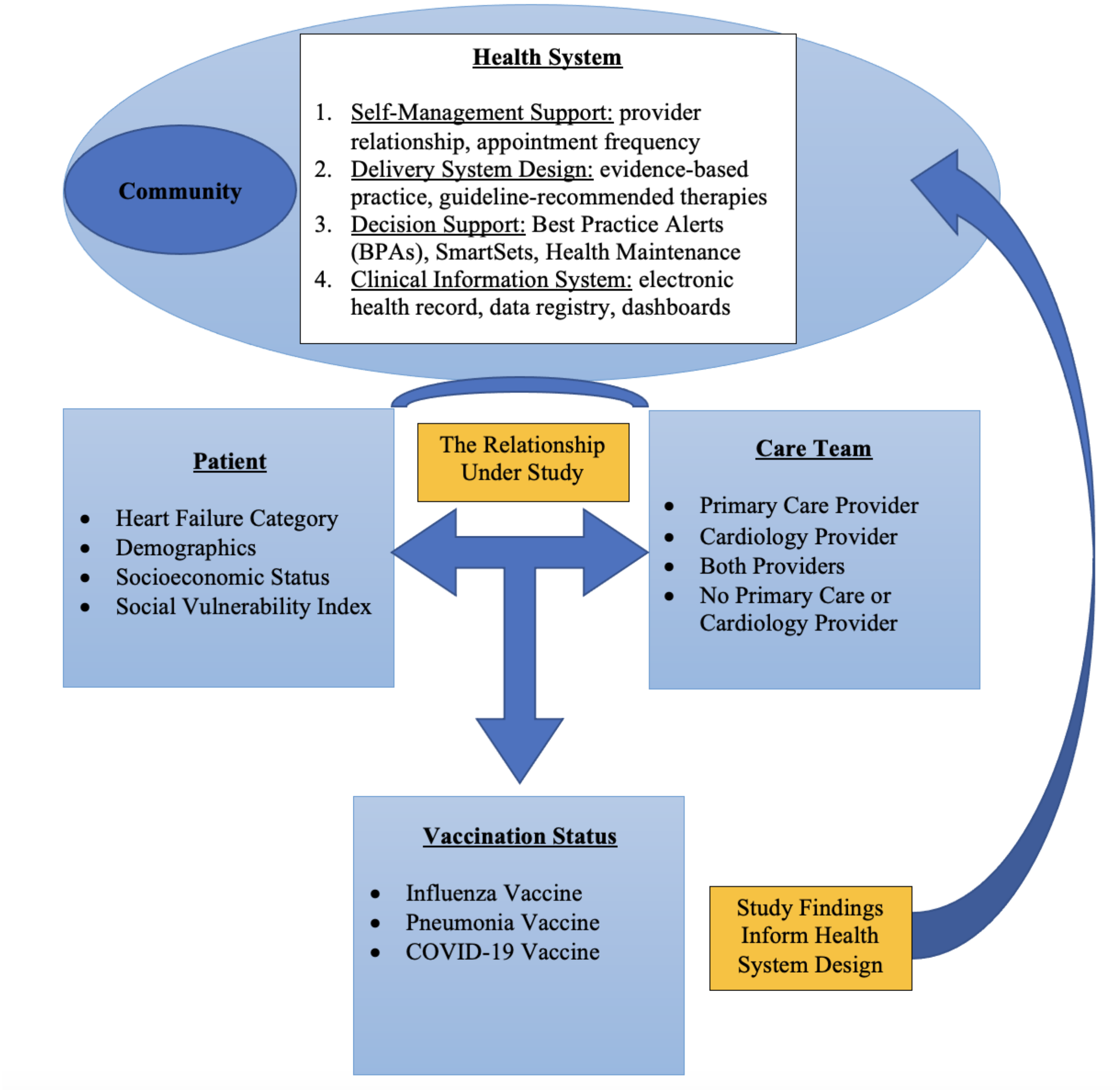
Despite its limitations, the CCM provides a structure for patient-centered, population-level, team-based care that may positively impact outcomes for patients with heart failure. The CCM directs the health system to organize system-wide structures that can lead to better coordination of care. Electronic medical records and disease registries can establish patient-centered goals, monitor patient progress, and identify lapses in care based on the CCM. When care becomes consistent with evidence-based guidelines, patient outcomes improve [5, 20]. With their care teams, both primary care and cardiology providers can improve patient outcomes by delivering evidence-based care and office-based self-management education to improve vaccination rates in patients with heart failure.

Figure 3.1. The Chronic Care Model
The diagram summarizes the essential elements for improving chronic illness care at the following levels: community, health systems, practice team, and patient.



*Developed by The ACT Center, formerly known as the MacColl Center for Health Care Innovation, © ACP-ASIM Journals and Books, reprinted with permission from ACP-ASIM Journals and Book.

Figure 3.2. Conceptual Model and Key Variables
The Chronic Care Model as it applies to the *Respiratory Vaccinations in Heart Failure Patient Population* research study.



Chapter 4: Methodology

Introduction

Heart failure is a complex clinical syndrome, and its progression can vary among individuals based on genetic, environmental, and lifestyle factors within a population. Heart failure affects people of all ages and is the leading cause of death for both genders in most racial and ethnic groups [3, 15]. It is responsible for 3.3 million clinic visits each year, and it is the most common diagnosis in hospital patients aged 65 years or older [1, 3]. Respiratory infections such as influenza, pneumonia, and COVID-19 make heart failure worse. Vaccines are available to prevent a number of respiratory diseases, but it is underutilized as an evidence-based preventive practice. Improvement in health behaviors and preventive practices like getting appropriate vaccinations are critical to managing heart failure.

Background

All cases of heart failure can be classified as diastolic, systolic (including combined systolic/diastolic), and mid-range [20, 21]. In diastolic failure or dysfunction, the left ventricle loses its ability to relax normally due to the heart muscle becoming stiff. The heart can't properly fill with blood during the resting period between each beat. Diastolic failure is classified as heart failure with preserved ejection fraction (HFpEF). In systolic or combined systolic/diastolic failure, the left ventricle loses its ability to contract normally and can't pump with enough force to push sufficient blood into circulation. Systolic failure is classified as heart failure with reduced ejection fraction (HFrEF). Another category that was created in 2016 is heart failure mid-range ejection fraction (HFmrEF), also known as borderline ejection fraction (HFbEF) [19]. This category was previously treated as HFpEF. When a specific diagnosis has not been established in any of these categories, a general heart failure unspecified ejection fraction (HFuEF) is used.

Various studies have shown the benefits of vaccination for the prevention of disease and management of chronic disease [27, 66]. Despite being an easily accessible intervention, vaccines are underused in patients with heart failure [12]. The recommended vaccinations can reduce the incidence as well as the severity of infections. However, the vaccination recommendations and preventive screenings are limited in most of the current guideline recommendations (American Heart Association/American College of Cardiology Foundation [AHA/ACCF], Heart Failure Society of America [HFSA], and European Society of Cardiology [ESC]). However, there is a consensus to provide influenza, pneumococcal, and COVID-19 vaccines to all patients in the absence of known contraindications [4]. Vaccinations are low-cost interventions that may be able to prevent the significant morbidity, mortality, and system-wide cost associated with heart failure.

In the U.S., an annual influenza vaccine (1 dose) is recommended for anyone six months and older. Pneumococcal vaccines are recommended as part of the child and adult immunization series. Two kinds of pneumococcal vaccines are used in the U.S.: (1). Pneumococcal conjugate vaccines (PCV13, PCV15, or PCV20); (2). Pneumococcal polysaccharide vaccine (PPSV23). Adults who have never received a pneumococcal conjugate vaccine should receive PCV15 or PCV20 if they are 65 years and older or are 19 through 64 years old and have certain medical conditions or other risk factors. If PCV15 is used, it should be followed by a dose of PPSV23 [67]. As of this study, COVID-19 primary series vaccination is recommended for everyone ages five years and older to prevent COVID-19. A 3-dose primary mRNA COVID-19 vaccine series is recommended for people ages five years and older who are moderately or severely immunocompromised, followed by a booster dose in those ages 12 years and older. Efforts to increase the number of patients who are up to date with their vaccinations remain critical to preventing illness, hospitalizations, and deaths from respiratory illnesses.

This research aims to study the vaccination rates of influenza, pneumococcal, and COVID-19 among a stratified heart failure patient population in relation to patient and provider factors. The conceptual framework from the Chronic Care Model guides the research design. An analysis is done to understand the relationship between patient factors (heart failure category, demographics, socioeconomic status, and social vulnerability index) and care team factors (primary care provider, cardiology provider, both providers, and no primary care or cardiology provider registered in the health system) in association with vaccination status (influenza, pneumococcal, COVID-19). The goal of this study is to identify strategies that can improve the equitable and optimal implementation of vaccines in ambulatory care practices.

Research Question

What patient and provider factors are associated with respiratory vaccination status among patients with heart failure that could lead to improvements in preventive care delivery?

Specific Aims

1. Examine whether there are differences in vaccination status for three recommended respiratory vaccines (influenza, pneumococcal, COVID-19) among patients with four types of heart failure (heart failure with preserved ejection fraction [HFpEF], heart failure with mid-range ejection fraction [HFmrEF], heart failure with reduced ejection fraction [HFrEF], heart failure unspecified ejection fraction [HFuEF]), controlling for patient and provider factors.

Hypothesis: Patients in more severe heart failure categories will have higher levels of vaccination compared to patients with less severe heart failure, independent of patient and provider factors.

2. Explore what patient factors (heart failure category, gender, age, race/ethnicity, language, accountable care organization [ACO] status, insurance) are associated with vaccination status (influenza, pneumococcal, and COVID-19), controlling for provider factors.

   Hypothesis: Patients with sociodemographic vulnerabilities will have lower levels of vaccination, independent of provider factors.

3. Investigate whether there is an association between provider type (primary care provider, cardiology provider, both providers, no primary care or cardiology provider registered in the health system) and patient vaccination status (influenza, pneumococcal, and COVID-19), controlling for patient factors.

   Hypothesis: Having a primary care provider compared to other provider types will positively correlate with vaccination status independent of patient factors.

Methods

This applied quantitative cross-sectional research pulled data from the UCLA Health Heart Failure Registry (N=7341) for secondary data analysis. The registry had information on patient demographics (i.e., gender, age, ethnicity, race, primary language, patient geographic region); socioeconomic status (i.e., accountable care organization [ACO] status, financial class, financial strain, food insecurity worry); social vulnerability index (SVI); proactive care risk; co-morbidities (i.e., ischemic disease, diabetes, hypertension, chronic kidney disease stage 3 or above, advance illness); hypertension control; guideline-recommended medications (i.e., angiotensin-converting enzyme [ACE] inhibitors, angiotensin receptor blockers [ARB], angiotensin receptor-neprilysin inhibitors [ARNIs], aldosterone antagonists [MRA], beta blockers [metoprolol succinate, carvedilol, or bisoprolol], hydralazine and isosorbide for self-identified as Black or African-American, Sodium-glucose Cotransporter-2 [SGLT2] inhibitors); heart failure medication count; vaccination status for influenza, pneumococcal, and COVID-19; ejection fraction rate and value; primary care and cardiology provider name and practice; and advance care planning. Measure definitions and exclusions are included in Table 4.1. The population-level data is visualized in a Tableau dashboard (Figure 4.1), and Heat Map provides a visual summary of patient demographics based on postal code (Figure 4.2).

Data Collection

The purpose of the Heart Failure Registry was to identify and reduce care gaps with the use of guideline-directed medical therapies (GDMT) for UCLA Health patients. The registry built was completed in early 2022 with a three-year data lookback period. A testing phase was conducted by a team of primary care and cardiology providers, quality specialists, and computer programmers and analysts during a six-month period to establish a high level (90% or above) of sensitivity (i.e., true positive rate - correctly identifying patients with heart failure) and specificity (i.e., true negative rate - correctly excluding patients without heart failure). For this registry, the heart failure diagnosis was captured from the Electronic Health Record (EHR) Problem List. The problem list was updated by clinicians who are members of the patient's care team in the ambulatory care and inpatient settings. For the patient to be included in the registry, there must be a heart failure diagnosis on the problem list.

A Best Practice Alert (BPA) was developed in the EHR to help primary care and cardiology providers identify and classify adult patients with heart failure onto the problem list. The BPA was activated if any of these criteria are triggered: (1) past encounter diagnosis code of heart failure, (2) left ventricular ejection fraction ≤ 40% in the last three years, (3) unspecified heart failure on the problem list, and (4) medication Entresto (sacubitril-valsartan). These criteria made up the “suspected heart failure” list, where there was a high likelihood that a patient has a diagnosis of heart failure that was not yet added to the problem list. The BPA was a decision support tool in the EHR that is a pop-up during a patient encounter. It provides targeted patient-specific clinical guidance based on clinical data already available in the EHR. Over time, the BPA would increase the overall number of patients with heart failure in the registry and decrease the number of suspected and unspecified heart failure. This process was an active push to refine generic heart failure diagnoses to more specific ones as problems become more specific during the course of patient treatment.

Aim Specific Measure Definitions

Heart Failure Categories

There are over 72,000 diagnosis codes identified by the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) handbook. Around 2,000 (3%) ICD-10-CM codes/subsets were associated with a heart failure diagnosis that can end up on the problem list. These various ICD-10-CM diagnosis codes were pulled from the problem list into the registry and categorized under four heart failure groups:

1. Heart Failure preserved Ejection Fraction (HFpEF) - list of 484 EHR diagnosis IDs linked to ICD-10-CM diagnosis codes.
2. Heart Failure mid-range Ejection Fraction (HFmrEF) - list of 9 EHR diagnosis IDs linked to ICD-10-CM diagnosis codes.
3. Heart Failure reduced Ejection Fraction (HFrEF) - list of 703 EHR diagnosis IDs linked to ICD-10-CM diagnosis codes.

4. Heart Failure Unspecified Ejection Fraction (HFuEF) - list of 763 EHR diagnosis IDs defined by general ICD-10-CM codes not specific to reduced or preserved ejection fraction.

Primary Care and Cardiology Provider Attribution

An attribution model was selected to increase the identification of the patient population the providers and care teams are responsible for when managing patient panels. The primary care attribution is designated when a primary care provider (PCP) is listed in the "PCP" field in the EHR who saw the patient at least once in the past three years. If there is no PCP designated in the "PCP" field and the patient has seen a PCP in the last three years, the attribution becomes based on the number of visits. Cardiology attribution is designated from the "Care Team" section of the EHR. If there is no cardiology provider listed in the "Care Team" section and the patient has seen a cardiology provider at least two visits in the last two years and the last visit within 18 months, the attribution becomes based on the number of visits. The measure for both providers accounts for both the PCP and Cardiology providers. The non-UCLA provider attribution is for any patient who does not have a UCLA PCP or Cardiology listed in the EHR.

Patient Demographics

Patient demographics include gender, age, race, ethnicity, and primary language.

1. Gender is captured as female, male, other, unknown, x.
2. Age is a continuous variable between 18 to 110 or can be analyzed as a categorical variable <65, ≥65.
3. Race/Ethnicity is stratified under Asian, Black, Hispanic, White, Other (includes American Indian/Alaskan Native, Native Hawaiian/ Pacific Islander, and Unknown)
4. Primary language is categorized as English and Non-English/Unknown.

Socioeconomic Status

Socioeconomic status encompasses individual, household, or community access to resources. It is often measured as a combination of education, income, and occupation. The measures captured in the database include accountable care organization (ACO) status, financial class, and financial strain.

1. ACO status is a dichotomous value, yes or no. UCLA Health is currently participating in CMS Medicare Shared Savings Plan, Anthem Blue Cross PPO Enhanced Care Coordination, Cigna Collaborative Accountable Care, and Health Net Blue & Gold ACO.
2. Financial class is categorized into the following: Commercial (includes TriCare, Group Health Plan), Medicaid (includes MediCal Assigned), Medicare (includes Medicare Advantage, Medicare Assigned), UCLA Managed Care, and Other (includes International Payor, Package Billing, Self-Pay, Worker's Comp).
3. Financial strain is categorized into very hard, hard, somewhat hard, not very hard, not hard at all, unknown.

Social Vulnerability Index (SVI)

SVI is a continuous variable and is categorized into the following scores for resource allocation: ≤50, >50 to <70, >70 to <80, >80 to ≤90, >90, unknown. The higher the score, the higher the vulnerability. SVI measures the potential negative effects on communities caused by external stresses, including natural or human-caused disasters or disease outbreaks on human health. The CDC/ATSDR SVI uses U.S. Census data to determine the social vulnerability of every census tract. Census tracts are subdivisions of counties for which the Census collects statistical data. The CDC/ATSDR SVI ranks each tract on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes. Each track receives a separate ranking for each of the four themes and an overall ranking. The UCLA EHR uses the physical address to map the SVI score. In California, not all addresses are mapped to the Census Tract due to their geographical location. Therefore, there are some missing SVI values in the EHR.

Proactive Care Risk

The UCLA Health proactive care risk is a population-based risk model that uses around 150 variables from the medical records to predict the risk of non-maternity, non-trauma hospital admission, or emergency department visits in the next 12 months. Risk is categorized into highest risk, high risk, rising risk, and no risk. The highest risk is defined as the top five percent of the at-risk population. The at-risk population is defined as all patients with a predicted future risk of greater than 35 percent. The high risk is for patients with predicted future risk greater than 35 percent, and two or more emergency department visits and one or more admissions in the prior year. Rising risk is for patients with predicted future risk greater than 35 percent, with zero or one emergency department visit in the prior year and no admissions in the prior year. The null category captures patients who have no risk.

Vaccination Status

Vaccination status is pulled into the Heart Failure Registry from the Immunizations and Injections section of the EHR. The data includes external and internal (domestic) sources. External immunization records are pulled from the California Immunization Registry (CAIR2) and Epic Care Everywhere. The CAIR2 is a secure, confidential, statewide computerized immunization information system for California residents. Care Everywhere allows health systems to share medical records with other health systems if using the same EHR. Individual vaccine data will be analyzed for influenza, pneumococcal, and COVID-19 vaccines. The Heart

Failure Registry counts a measure fully vaccinated for each vaccine when the following numerators are met:

1. Influenza vaccine: documentation of immunization ID (42 total) or professional billing charge (20 total) in the EHR. The influenza vaccination period is from August of the previous year to March of the current year.
2. Pneumococcal vaccine: documentation of one dose of pneumococcal polysaccharide vaccine 23-valent (Pneumovax) or pneumococcal conjugate vaccine 13-valent (Prevnar). No time specified. The new Prevnar 20 will be available at UCLA Health soon. This vaccine helps protect against 20 types of pneumococcal bacteria and will replace Prevnar 13. The registry logic will be updated to include this new vaccine.
3. COVID-19 vaccine: documentation of two doses for the mRNA manufacturers, one dose for Jansen, or one dose for unspecified. No time specified.

Data Analysis

Institutional Review Board (IRB) approval was requested from the University of California Los Angeles. After IRB approval, the Heart Failure Registry team programmer pulled the most current population data in Microsoft Excel and de-identified the data by removing name and medical record number before providing it to the researcher in a secure file. The researcher coded the data and created a data dictionary to identify the variables included in the analysis. An R statistical software was used to manage the data and perform advanced analytics and multivariate analysis.

Descriptive statistics, bivariate tests, and multiple logistic regression analysis was conducted to study the relationship between independent variables (patient factors and care team) on the dependent variable (vaccination status). Descriptive statistics and frequencies characterized the sample on all analytic variables. This process quantified the population to provide basic information about the variables in the dataset and highlighted potential relationships between variables such as the heart failure categories, provider involvement, and vaccination status. Bivariate test (chi-square tests for categorical variables) was used to compare sample differences by heart failure category and demographic and social characteristics. Multiple logistic regression models examined the odds of vaccination for patient and provider factors, adjusted for covariates. Three separate models were estimated for each vaccination status outcome.

Discussion

UCLA Health is committed to being an integrated health system, delivering care to hundreds of thousands of patients across the region, and providing excellent tertiary and quaternary care. There is a great need to have the right care at the right time in the right setting for a large population of diverse patients. In Department of Medicine, the vision is to provide comprehensive, coordinated care in the communities where the patients work and live and deliver high-quality and equitable care on an individual and population level. Designing robust data systems to understand and track a complex population like heart failure can create structure, process, and outcomes to improve the health of the population.

Primary care and cardiology providers know the importance of preventive care measures. However, primary care providers have workflows through the EHR that help them quickly identify care gaps for a patient during a visit. The Health Maintenance section in the EHR is a preventive care tracking tool used to remind providers, care teams, and patients about completed and upcoming preventive health tests and procedures. Using Health Maintenance, providers can track vaccination status and routine screening tests to manage patients with chronic diseases.

When a patient becomes due for preventive care, the system notifies the providers and their care teams. Patients can also view the due status of preventive care topics in their patient portal if they have an active account. This process helps patients engage in their health by providing evidence-based recommendations specific to their age, gender, and disease.

Primary care providers use this EHR tool regularly as part of their interaction with the patient. The Care Gaps SmartSet for Providers which are group orders is the most used SmartSet in primary care and makes it easy to address chronic disease and preventive health care gaps. Cardiology providers utilize individual note templates to keep track of guideline-recommended therapies, but there is no system in place to nudge them about preventive items like vaccinations. In an integrated health system, EHR tools such as the Problem List, Health Maintenance, SmartSets, BPAs, can be optimized to meet the needs of all providers and care teams within the system. Engaging specialty providers to close preventive care gaps targeted to their population of patients will increase the shared goal of improving care throughout the system.

Specifically, the results of this study can inform leadership and stakeholders about patient, provider, and system factors that affect vaccination outcomes in the heart failure patient population. The data can highlight gaps in care and direct efforts to optimize workflow interventions that improve care processes and outcomes. The data transparency through the Heart Failure Dashboard can provide clinical benchmarks to providers and care teams and drive improvement efforts within individual regions and clinics. The overall effort can improve quality, safety, and efficiency throughout the healthcare system.

Innovative Data Registry

Most traditional healthcare studies commonly use administrative coding data to study the population, process, and outcomes. Administrative coding data is used to study the prevalence and incidence of major diagnoses and diseases and the utilization of specific services and procedures. Algorithms based on discharge and procedure codes are increasingly used to evaluate performance, resource needs, and quality of care. The strength of using administrative data to study heart failure includes getting a large sample size and a systematic collection of data over time. The limitations of using such data include the lack of accuracy, variation in coding criteria across individuals and institutions, changing criteria over time, changes in the coding system over time, and lack of real-time application to clinical management [68].

To focus on diagnosis based on clinical relevance and address some of the barriers with administrative coding, the Heart Failure Registry is based on the problem list. The problem list in the EHR is a central place for clinicians to obtain a comprehensive and concise view of all the patient's medical problems. It is the primary means in the EHR for communicating important aspects of the patient's ongoing care across all areas of patient care and is a central part of their care plan over time. The problem list is updated by clinicians who are members of the patient's care team in the ambulatory care and inpatient settings. There is also an active push to refine generic diagnoses to more specific diagnoses as problems become more specific during the course of patient treatment. Having an accurate problem list helps provide the best quality care and the highest measure of patient safety and comply with Meaningful Use regulation.

A patient registry can classify patients who meet the criteria for a disease or high level of suspicion of disease based on laboratory values, risk scores, etc., but no diagnosis (i.e., suspected heart failure). The BPA can activate based on the medical history or billing data. The algorithm will notify the provider that heart failure diagnosis is not on the problem list based on documentation in the medical history, one or more billing codes, ejection fraction value, or prescriptions of heart failure medications. If the ICD-10 code is systolic or systolic and diastolic heart failure, the provider categorizes the patient under systolic (HFrEF) diagnosis. If the ICD-10 code is diastolic heart failure, the provider categorizes the patient under diastolic (HFpEF) diagnosis. If there is no specification, the BPA will prompt the provider to categorize the patient either under systolic (HFrEF), mid-range (HFmrEF), or diastolic (HFpEF). These categories then get added to the problem list, and it signals the program to list the patient in the Heart Failure Registry.

The Heart Failure Registry feeds the data into a Tableau dashboard, where it provides population-level data and rates on performance and outcomes measures. The data is relevant and actionable for each provider and practice location. The dashboard allows providers and care teams to target key quality metrics, track progress, and compare individual efforts with clinics and colleagues across the health system. Having benchmarks helps providers and their care teams understand their individual and clinic performance compared to their peers and assess how a change in protocol or a quality improvement initiative is working. Data transparency and incentive models based on process and outcome measures can increase compliance with guideline-recommended therapies.

The UCLA Heart Failure Registry is modeled after the IMPROVE-HF Registry, an extensive outpatient HFrEF registry of more than 165 clinics created in 2005 and studied throughout the years with 34810 participants. IMPROVE-HF Registry tracks seven performance measures: ACEi/ARB, beta blocker, MRA, anticoagulation for atrial fibrillation, Cardiac Resynchronization Therapy (CRT), Implantable cardioverter-defibrillator (ICD), and heart failure education. The data transparency over time has been associated with improvements in the use of guideline-directed medical therapies (GDMT) in eligible patients in outpatient clinics [5]. Clinical and operation data can be used to manage populations directly.

One way to assess high-quality and equitable outcomes between patient populations is to develop robust data systems and interactive dashboards. These dashboards can identify areas of service or outcome inequities among racial/ethnic, gender, or socioeconomic groups. The data can help guide interventions to incorporate vulnerability indices and prediction tools to provide additional support to patients to meet unmet medical and social needs.

Limitations

Some health system factors that could impact the data include a limited supply of vaccines in the cardiology clinics, which may affect provider prescribing habits and patient access to vaccinations. Additionally, current vaccine guideline recommendations are limited to specific age and disease categories and are not covered by all insurances. For example, the pneumococcal vaccine is recommended for 65 years of age or older and 19 through 64 years of age who have certain medical conditions or other risk factors. Some younger patients might find it difficult to get coverage for the pneumococcal vaccine through their insurance.

Conclusion

Understanding healthcare provider practices in vaccination outcomes can help improve preventive care practices in chronic disease management. Creating standardized systems and applying implementation science methods and strategies can facilitate the uptake of evidence-based practice into the daily workflows of providers and care teams.

Table 4.1. Heart Failure Registry Measure Definitions
Process and outcome measure definitions for specific measures in the heart failure registry.

Measure Name	Definition
All patients with Heart Failure (HFrEF, HFpEF, HFmrEF, HFuEF) on the problem list	Includes all patients who meet all the following criteria: 1. Ambulatory visit with any provider in the last 3 years 2. HFrEF, HFpEF, HFmrEF, or HFuEF on the problem list 3. Patients 18 and older 4. Excludes Heart Transplant, VAD, and Hospice Patients
Heart Failure reduced Ejection Fraction (HFrEF) on the problem list	Includes all patients who meet all the following criteria: 1. Ambulatory visit with any provider in the last 3 years 2. HFrEF in the problem list 3. Age 18 and older 4. Excludes Heart Transplant, VAD and Hospice Patients
Heart Failure preserved Ejection Fraction (HFpEF) on the problem list	Includes all patients who meet all the following criteria: 1. Patient had an ambulatory visit with any provider in the last 3 years 2. HFpEF on the problem list: 3. Patients 18 and older
Heart Failure Mid-Range/Borderline Ejection Fraction (HFmrEF or HFbEF) on the problem list	Includes all patients who meet all the following criteria: 1. Patient had an ambulatory visit with any provider in the last 3 years 2. HFmrEF or HFbEF on the problem list 3. Patients 18 and older
Heart Failure Unspecified Ejection Fraction (HFuEF) on the problem list	Includes all patients who meet all the following criteria: 1. Patient had an ambulatory visit with any provider in the last 3 years 2. HFuEF on the problem list 3. Patients 18 and older
Percent of HFrEF Patients on Beta Blocker	Among patients with active HFrEF diagnosis on the problem list, percent on beta blockers.
Percent of HFrEF Patients on ACE, ARB, OR Ernesto/ARNI	Among patients with active HFrEF diagnosis on the problem list, the percent on ACE or ARB or Entresto/ARNI. Exclusions include CKD Stage 5; CKD ESRD; Prior Dx Hyperkalemia E87.5.
Percent of HFrEF Patients on MRA Therapy	Among patients with active HFrEF diagnosis on the problem list, the percent on MRA. In presenting denominator eligible patients, use the algorithm below: 1. If HFrEF present on the problem list (regardless of EF) AND current meds includes MRA (spironolactone or eplerenone) – INCLUDE, Denominator 1, Numerator 1 2. If HFrEF is present on the problem list AND current meds do not include MRA (spironolactone or eplerenone) AND LVEF ≤35%, INCLUDE, Denominator 1, numerator 0 3. If HFrEF is present on the problem list AND current meds do not include MRA (spironolactone or eplerenone) AND

	LVEF >35%, DO NOT INCLUDE, Denominator 0, Numerator 0 4. Patients who do not need to be in MR 5. Excludes: Hyperkalemia, CKD Stage 4 CKD Stage 5, CKD ESRD
Percent of HFrEF Patients on SGLT2 Therapy	Among patients with active HFrEF diagnosis on the problem list, the percent currently on SGLT2. Excludes CKD Stage 4and CKD Stage 5, CKD ESRD.
Percent of HFrEF Patients on Hydralazine/Isosorbide Therapy in those self - identified as Black or African American	Among patients with active HFrEF diagnosis on the problem list, the percent on Hydralazine/Isosorbide Therapy in those self-identified as Black or African America. Patients must be on both medications to be numerator compliant.
Percent of HFrEF and GDMT Patients on CRT Implant	Among patients with active HFrEF diagnosis on the problem list, percent on CRT Implant defined as: 1. LVEF less than or equal to 35% 2. ECG Diagnosis of Sinus Rhythm or Sinus Bradycardia or Sinus Tachycardia 3. AND Left Bundle Branch Block with QRD > 120 ms or Left Bundle Branch Block not present and QRS > 150ms 4. Exclude Palliative Care of Hospice Patients
Percent of Heart Failure Patients with LVEF Assessment	Among patients with active heart failure diagnosis on the problem list, the percent with LVEF Assessment from the incentive program specific Echocardiograms. There is no look back period for the ejection fraction.
Percent of Heart Failure Patients with Pneumococcal Vaccination	Among patients with active heart failure diagnosis on the problem list, the vaccination rate for pneumococcal vaccine (Prevnar or Pneumovax).
Percent of Heart Failure Patients with Influenza Vaccination	Among patients with active heart failure diagnosis on the problem list, the vaccination rate for influenza vaccine. Influenza vaccination period occurs August of the previous year to March of the current year.
Percent of Heart Failure Patients with COVID-19 Vaccination	Among patients with active heart failure diagnosis on the problem list, the % with full vaccination for COVID vaccine.
Percent of Heart Failure Patients with Blood Pressure Control	Among patients with ages 18 and above, two BP readings in the past 3 years and active heart failure diagnosis on the problem list, the percent with the last ambulatory bp readings less than 140/90 within the last 3 years. 1. For 2+ BPs in one day chose one with lowest MAP (Sys +2(Dia))/3. 2. For numerator compliance, there must be two consecutive BP readings where at least 1 is less than 140/90. 3. For numerator non-compliance, there must be two consecutive BPs with both readings of greater than 140/90.

Percent of Heart Failure Patients with Enduring Advanced Directives	Among patients with active heart failure diagnosis on the problem list and ages ≥65 OR active heart failure patients over 18 with any of the following diagnoses: HFrEF, Heart Transplant, and LVAD.
Heart Failure Patients in a CMY MP1 Clinic	Among patients with active heart failure diagnosis on the problem list, the percent of patients in a Cardiomyopathy Clinic (i.e., advance heart failure clinic).

Figure 4.1: Heart Failure Tableau Dashboard

A data visualization that allows for interactive data visualization. The user can build, query, display, analyze, filter, sort, group, drill down, drill up, calculate, organize, summarize, and present data in various ways.

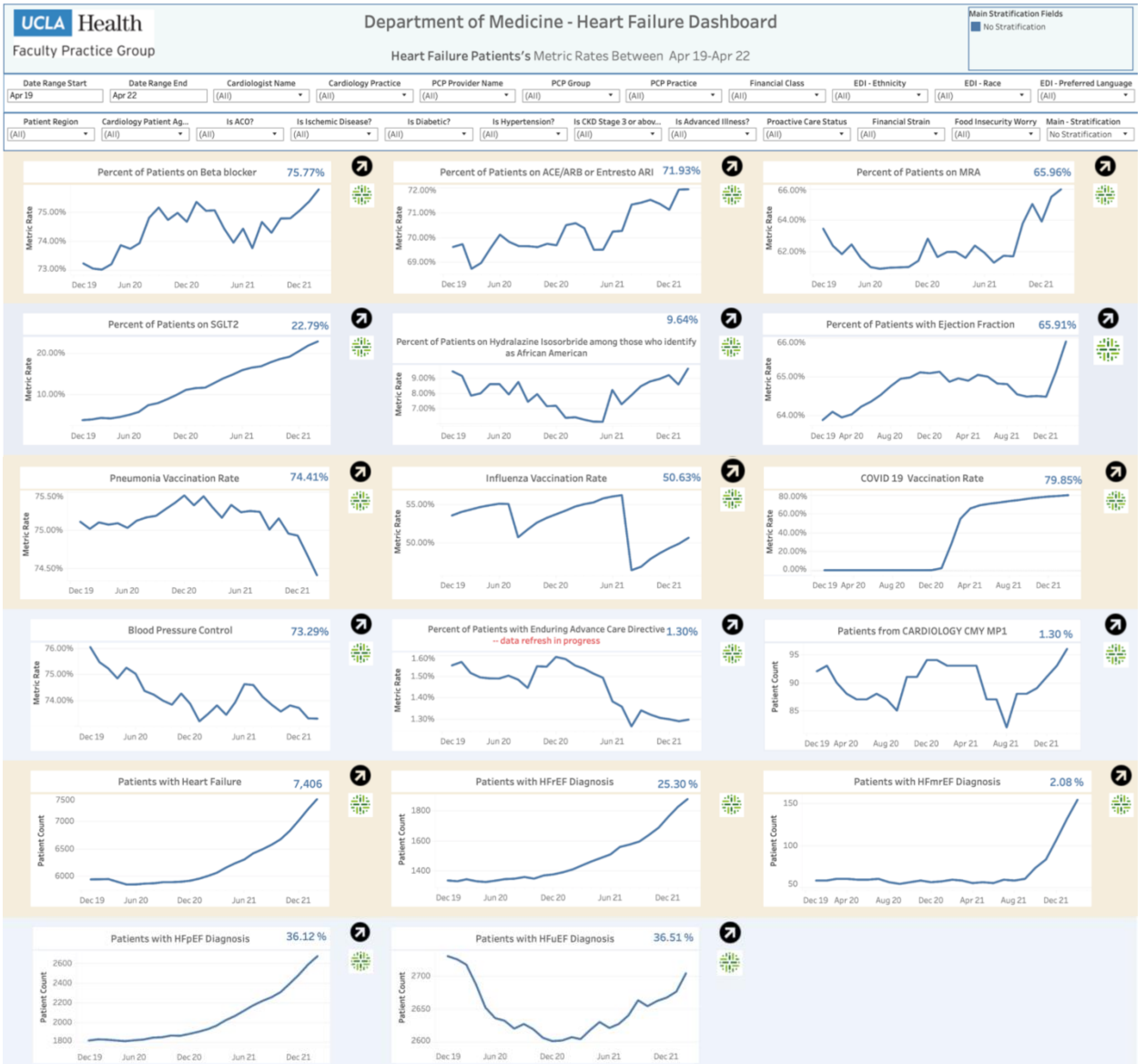
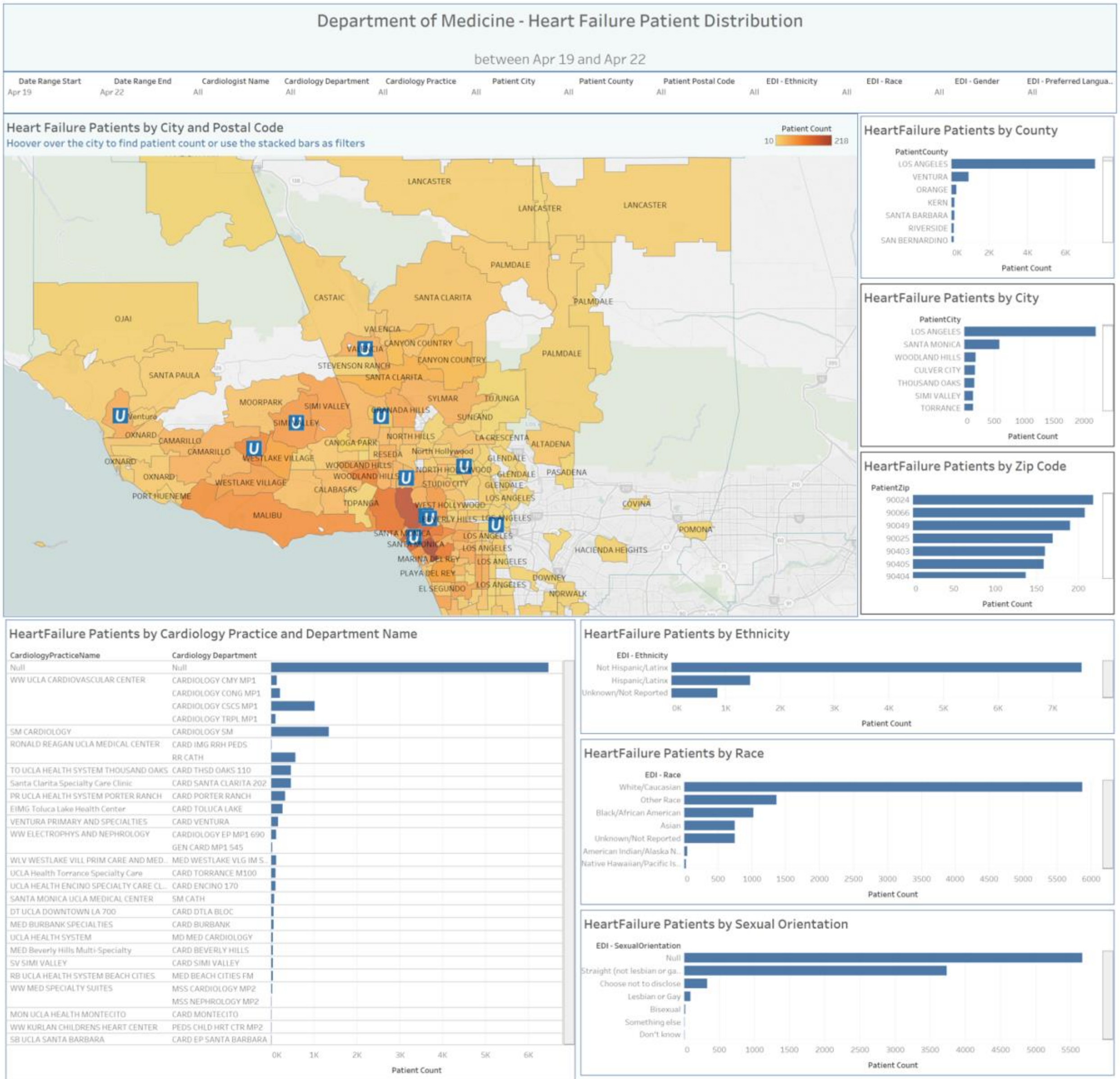


Figure 4.2. Heat Map of Heart Failure Patient Population
A visual summary of patient demographics based on postal code.



Chapter 5: Results

Introduction

Heart failure is associated with considerable morbidity, mortality, and cost. Respiratory infections cause significant disease and poor outcomes in patients with heart failure. Influenza, pneumococcal, and COVID-19 vaccines can help protect the cardiac muscle and reduce the incidence of respiratory infections. Multiple studies have shown the benefits of vaccination for preventing and managing heart disease. Despite being an easily accessible intervention, vaccinations are underutilized and understudied in patients with heart failure. Understanding patient and provider factors that influence vaccination rates can guide population-level interventions to improve vaccination outcomes. The purpose of this study was to describe the vaccination rates of influenza, pneumococcal, and COVID-19 among a stratified heart failure patient population, identify patient factors associated with vaccination, and examine the association between provider type and vaccination status.

Methods

An observational study was conducted using data from a health system Heart Failure Registry from 2019 to 2022. The conceptual framework used to inform the study was the Chronic Care Model. The Heart Failure Registry contained adult patients (N=7341) with heart failure and data about their demographics, clinical and social characteristics, treatment background, and provider type. Descriptive statistics and frequencies were used to characterize the sample on all analytic variables. The primary dependent variable was vaccination status (influenza, pneumococcal, COVID-19). The independent variables were patient status (heart failure category, demographics, socioeconomic status, social vulnerability index [SVI]) and provider type (primary care provider, cardiology provider, both providers, and no primary care or cardiology provider registered in the health system). Bivariate test were used to compare sample differences by heart failure category and demographic and social characteristics. Exploratory multiple logistic regression models were used to examine the odds of vaccination from patient and provider factors, adjusted for other covariates.

Data Analysis

Data cleaning in excel included combining race and ethnicity into one measure to align with new racial categories used by the U.S. Census Bureau, where Hispanic was now considered a race. American Indian/Alaskan Native and Native Hawaiian/ Pacific Islander were combined in the "Other" category due to low number counts. The final race/ethnicity categories included (1) Asian, (2) Black, (3) Hispanic, (4) White, and (5) Other. For financial class, similar categories were combined into five total insurance types: (1) Commercial - Commercial, Group Health Plan, and Tricare, (2) Medicaid – MediCal and MediCal Assigned, (3) Medicare – Medicare, Medicare Advantage, Medicare Assigned, (4) UCLA Managed Care, and (5) Other - International Payor, Package Billing, Self-Pay, and Worker's Comp. Finally, the SVI categories (<50, ≥50 to <70, ≥70 to <80, ≥80 to ≤90, >90, unknown) were recategorized into four groups: (1) high risk (score >90), (2) medium risk (score 50 to 90), (3) low risk (score <50), and (4) unknown risk.

RStudio program was used for statistical computing and analysis. The initial analysis included the variables of financial strain, social vulnerability index (SVI), and proactive care risk scores. After examining the financial strain category, the variable was removed due to the small sample size. A new variable was created for the patients who were missing scores for the SVI (N=259 missing) and proactive care risk (N=6006 missing). A chi-square test was done to compare if the patients that were missing were different from those who had complete data on key demographic variables and outcome variables (vaccination status). For SVI, there were statistically significant differences between missing/non-missing patients on all variables, but the magnitude of these differences was minimal (within 1% point for all variables). Since social vulnerability is an important concept for vaccination outcomes and the number of missing was small, the SVI variable was included in the final model. For proactive care risk, there were statistically significant differences between missing/non-missing patients that were larger in magnitude (up to 15% difference for some outcome variables). This variable was removed from subsequent analysis.

Initial cross tabs were done to examine the overlap of Medicare and Age ≥65 variables. Eighty-one percent of patients (N=4440) over age 65 years had Medicare. While there was significant overlap between the two variables, approximately one-fifth of patients over 65 years were not covered by Medicare. To understand the insurance and age interaction further, a new measure was created for Age ≥65 with each insurance category (Medicare, Medicaid, Commercial, UCLA Managed Care, and Other). The interaction between Age and Medicare was significant in Influenza ($p<0.01$) and Pneumonia ($p<0.01$) outcomes. Based on these findings, a new variable for the interaction was included in the final regression model, in addition to the age and insurance variables.

Before the final analysis, reference categories and variable structure were programmed in R. Multiple logistic regression models were estimated to examine the odds of vaccination among patients with four heart failure types, patient factors, and provider types while adjusting for covariates. Table 5.1 shows differences between heart failure categories on analytic variables. Table 5.2 shows descriptive statistics summarizing patient and provider variables by vaccination rates. Table 5.3 shows an estimate of three multiple logistic models, one for each vaccination outcome (influenza, pneumococcal, and COVID-19) to address the three aims.

Results

Patient and provider characteristics of the heart failure population by vaccination status are presented in Table 5.2 and Figures 5.1-4. The profile of the population was 55.2% (N=4049) male, 74.5% (N=5467) aged 65 years or older, 52.9% (N=3886) White, 89.0% (N=6532) English speaking, and 66.1% (4851) have Medicare insurance. Of the total sample, 37.7 % (N=2764) were heart failure with preserved ejection fraction (HFpEF), 2.7% (N=198) were heart failure with mid-range ejection fraction (HFmrEF), 29.0% (N=2127) were heart failure with reduced ejection fraction (HFrEF), and 30.7% (N=2252) were heart failure unspecified ejection fraction (HFuEF). 30.7% (n=2256) had an SVI score of medium to high. The provider profile is 60.3% (N=4430) primary care, 52.6% (N=3863) cardiology, 36.4% (N=2675) both primary care and cardiology, and 23.5% (N=1723) no primary care or cardiology provider registered in the health system. An estimated 54.5% (N=4001) patients received an influenza vaccine, 74.7% (N=5483) received a pneumococcal vaccine, and 81.3% (N=5970) received a COVID vaccine.

In bivariate tests, there were significant differences in vaccination status by heart failure category ($p<0.01$), age ($p<0.01$), race/ethnicity ($p<0.01$), language (influenza and COVID-19 only) ($p<0.01$), ACO status ($p<0.01$), insurance ($p<0.01$), SVI ($p<0.01$), and provider type ($p<0.01$) (Table 5.2). In adjusted models, patients with preserved ejection fraction heart failure (OR=1.36, 95% CI=1.20-1.54) and mid-range ejection fraction heart failure (OR=1.41, 95% CI=1.02-1.96) had higher odds of being vaccinated for influenza compared to patients with unspecified heart failure. Patients with preserved ejection fraction heart failure had higher odds of being vaccinated (OR=1.32, 95% CI=1.14-1.53), and patients with reduced ejection fraction heart failure had lower odds of being vaccinated for pneumonia compared to patients with unspecified heart failure (OR=0.81, 95% CI=0.71-0.94). Patients with preserved ejection fraction heart failure had higher odds of being vaccinated for COVID-19 than those with unspecified heart failure (OR=1.27, 95% CI=1.09-1.49) (Table 5.3).

Influenza

In adjusted models, patients with heart failure preserved ejection fraction (OR=1.36, 95% CI=1.20-1.54) and heart failure mid-range ejection fraction (1.41, 95% CI=1.02-1.96) had higher odds of being vaccinated for influenza compared to unspecified heart failure patients. In addition, older patient age (OR=1.58, 95% CI=1.28-1.95), Asian (OR=1.23, 95% CI=1.00-1.51), Hispanic (OR=1.22, 95% CI=1.03-1.46), member of accountable care organization (OR=1.43, 95% CI=1.25-1.65), Medicare (OR=1.48, 95% CI=1.15-1.91), and Managed Care (OR 2.11, 95% CI=1.65-2.71) were associated with higher odds of vaccination status. In contrast, Black (OR=0.74, 95% CI=0.62-0.89), “Other” race (OR=0.78, 95% CI=0.67-0.91), non-English speaking (OR=0.65, 95% CI=0.55-0.78), Other insurance (OR=0.40, CI=0.27-0.58), SVI medium risk (OR=0.79, 95% CI=0.70-0.90), and SVI unknown risk (OR=0.51, 95% CI=0.38-0.67) were associated with lower odds of influenza vaccination status.

In models estimating odds of vaccination from provider type, patients with both primary care and cardiology providers (OR=1.79, 95% CI=1.57-2.05) had higher odds of vaccination compared to primary care provider alone. Patients with only a cardiology provider (OR: 0.84, 95% CI=0.72-0.99) or no primary care or cardiology provider registered in the health system (OR=0.34, 95% CI=0.29-0.40) had lower odds of influenza vaccination.

Pneumococcal

In adjusted models, patients with heart failure preserved ejection fraction (OR=1.32, 95% CI=1.14-1.53) had higher odds of being vaccinated for pneumococcal compared to unspecified heart failure patients. In addition, males (OR=1.26, 95% CI=1.12-1.42), older patient age (OR=3.22, 95% CI=2.59-4.02), Asian (OR=1.39, 95% CI=1.09-1.79), Hispanic (OR=1.50, 95% CI=1.23-1.84), member of accountable care organization (OR=1.73, 95% CI=1.45-2.09), Medicaid (OR=1.54, 95% CI=1.21-1.95), Medicare (OR=3.00, 95% CI=2.31-3.91), and Managed Care (OR=2.31, 95% CI=1.74-3.07) were associated with higher odds of vaccination status. In contrast, patients with heart failure reduced ejection fraction (OR=0.81, 95% CI=0.71-0.94), "Other" race (OR=0.62, 95% CI=0.53-0.72), non-English speaking (OR=0.82, 95% CI=0.67-0.99), and age interaction with Medicare (OR=0.52, 95% CI=0.37-0.71) were associated with lower odds of pneumococcal vaccination status. Being 65 years and older with non-Medicare insurance or younger than 65 years with Medicare insurance were associated with lower odds of pneumococcal vaccine.

In models estimating odds of vaccination from provider type, patients with cardiology provider (OR: 0.60, 95% CI=0.49-0.72) or no primary care or cardiology provider registered in the health system (OR=0.51, 95% CI=0.43-0.60) compared to primary care provider had lower odds of pneumococcal vaccination.

COVID-19

In adjusted models, patients with heart failure preserved ejection fraction (OR=1.27, 95% CI=1.09-1.49) had higher odds of being vaccinated for COVID-19 than unspecified heart failure patients. In addition, older patient age (OR=1.43, 95% CI=1.11-1.84), Hispanic (OR=1.26, 95% CI=1.02-1.57), member of accountable care organization (OR=1.92, 95% CI=1.55-2.38), and

Managed Care (OR=1.81, 95% CI=1.26-2.63) were associated with higher odds of COVID-19 vaccination status. In contrast, "Other" race (OR=0.82, 95% CI=0.69-0.97), non-English speaking (OR=0.69, 95% CI=0.56-0.85), Medicaid (OR=0.59, 95% CI=0.46-0.76), Other insurance (OR=0.40, 95% CI=0.28-0.57), SVI medium risk (OR=0.74, 95% CI=0.63-87), SVI high risk (OR=0.62, 95% CI=0.47-0.80), and SVI unknown risk (OR=0.36, 95% CI=0.28-0.48) were associated with lower odds of COVID-19 vaccination status.

In models estimating odds of vaccination from provider type, patients with cardiology provider only (OR: 1.32, 95% CI=1.07-1.63) and both primary care and cardiology provider (OR=2.11, 95% CI=1.74-2.56) had higher odds of vaccination compared to primary care provider alone. Patients with no primary care or cardiology provider registered in the health system had lower odds of COVID-19 vaccination (OR=0.52, 95% CI=0.44-0.62).

Aim Findings

Aim 1: Patients with the lowest-severity category of heart failure (EF≥50) had higher odds of receiving all three vaccines than patients whose heart failure type was unspecified. Patients with the highest severity category of heart failure (≤40) had lower odds of receiving a pneumococcal vaccine.

Aim 2: Patients identified as Black had lower odds of influenza vaccine than patients who identified as White. Patients categorized as "Other" race or who did not speak English as a primary language had reduced odds of receiving any of the three vaccines. Patients with Medicaid had lower odds of COVID-19 vaccination compared to commercial insurance. Patients with a social vulnerability index score of medium risk or unknown risk had lower odds of getting influenza or COVID-19 vaccines. Patients who were high risk had lower odds of getting the COVID-19 vaccine. Patients 65 years and older, Hispanic compared to White, accountable care organization member, or had managed care compared to commercial insurance, had higher odds of receiving all three vaccines. Patients identified as Asian or who had Medicare had higher odds of receiving influenza or pneumococcal vaccines. Additionally, patients who were male or had Medicaid had higher odds of getting the pneumococcal vaccine.

Aim 3: Patients with no primary care or cardiology provider registered in the health system had lower odds of receiving all three vaccines compared with patients with a primary care provider. There were also lower odds of influenza and pneumococcal vaccination for patients who had a cardiology provider but not a primary care provider. Patients who had both a cardiology provider and a primary care provider had higher odds of receiving an influenza vaccine and a COVID-19 vaccine than those with a primary care provider only.

Table 1. Differences between heart failure categories on analytic variables

	HFpEF 2764 (37.7%)	**HFmrEF** 198 (2.7%)	**HFrEF** 2127 (29.0%)	**HFuEF** 2252 (30.7%)	**Total** 7341 (100%)
Gender					
Female	1546 (55.9%)	75 (37.9%)	650 (30.6%)	1021(45.3%)	3292 (44.8%)
Male	1218 (44.1%)	123 (62.1%)	1477 (69.4%)	1231 (54.7%)	4049 (55.2%)
Age					
<65	398 (14.4%)	73 (36.9%)	722 (33.9%)	681 (30.2%)	1874 (25.5%)
≥65	2366 (85.6%)	125 (63.1%)	1405 (66.1%)	1571 (69.8%)	5467 (74.5%)
Race/Ethnicity					
Asian	205 (7.4%)	14 (7.1%)	142 (6.7%)	174 (7.7%)	535 (7.3%)
Black	268 (9.7%)	19 (9.6%)	224 (10.5%)	247 (11.0%)	758 (10.3%)
Hispanic	344 (12.4%)	21 (10.6%)	306 (14.4%)	325 (14.4%)	996 (13.6%)
White	1565 (56.6%)	119 (60.1%)	1072 (50.4%)	1130 (50.2%)	3886 (52.9%)
Other	382 (13.8%)	25 (12.6%)	383 (18.0%)	376 (16.7%)	1166 (15.9%)
Language					
English	2413 (87.3%)	184 (92.9%)	1917 (90.1%)	2018 (89.6%)	6532 (89.0%)
Non-English	351 (12.7%)	14 (7.1%)	210 (9.9%)	234 (10.4%)	809 (11.0%)
ACO					
Yes	754 (27.3%)	50 (25.3%)	446 (21.0%)	406 (18.0%)	1656 (22.6%)
No	2010 (72.7%)	148 (74.7%)	1681 (79.0%)	1846 (82.0%)	5685 (77.4%)
Insurance					
Commercial	257 (9.3%)	45 (22.7%)	444 (20.9%)	422 (18.7%)	1168 (15.9%)
Medicaid	78 (2.8%)	15 (7.6%)	194 (9.1%)	173 (7.7%)	460 (6.3%)
Medicare	2060 (74.5%)	117 (59.1%)	1258 (59.1%)	1416 (62.9%)	4851 (66.1%)
Managed Care	316 (11.4%)	20 (10.1%)	170 (8.0%)	165 (7.3%)	671 (9.1%)
Other	53 (1.9%)	1 (0.5%)	61 (2.9%)	76 (3.4%)	191 (2.6%)
SVI					
High Risk	116 (4.2%)	7 (3.5%)	131 (6.2%)	127 (5.6%)	381 (5.2%)
Medium Risk	623 (22.5%)	53 (26.8%)	591 (27.8%)	608 (27.0%)	1875 (25.5%)
Low Risk	1948 (70.5%)	135 (68.2%)	1320 (62.1%)	1423 (63.2%)	4826 (65.7%)
Unknown Risk	77 (2.8%)	3 (1.5%)	85 (4.0%)	94 (4.2%)	259 (3.5%)
Provider Type					
Primary Care	1952 (70.6%)	139 (70.2%)	1174 (55.2%)	1165 (51.7%)	4430 (60.3%)
Cardiology	1530 (55.4%)	154 (77.8%)	1280 (60.2%)	899 (39.9%)	3863 (52.6%)
Both Provider	1185 (42.9%)	113 (57.1%)	794 (37.3%)	583 (25.9%)	2675 (36.4%)
No Provider	18 (9.1%)	467 (16.9%)	467 (22.0%)	771 (34.2%)	1723 (23.5%)
Vaccination Type					
Influenza	1749 (63.3%)	129 (65.2%)	1075 (50.5%)	1048 (46.6%)	4001 (54.5%)
Pneumococcal	2288 (82.8%)	139 (70.2%)	1450 (68.2%)	1606 (71.3%)	5483 (74.7%)
COVID	2382 (86.2%)	175 (88.4%)	1683 (79.1%)	1730 (76.8%)	5970 (81.3%)

Notes. Each provider and vaccine type is an individual variable programmed as a dichotomous value (yes/no) in the dataset. Therefore, columns do not add up to 100%.

Table 2. Descriptive statistics for influenza, pneumococcal, and COVID-19 vaccinations

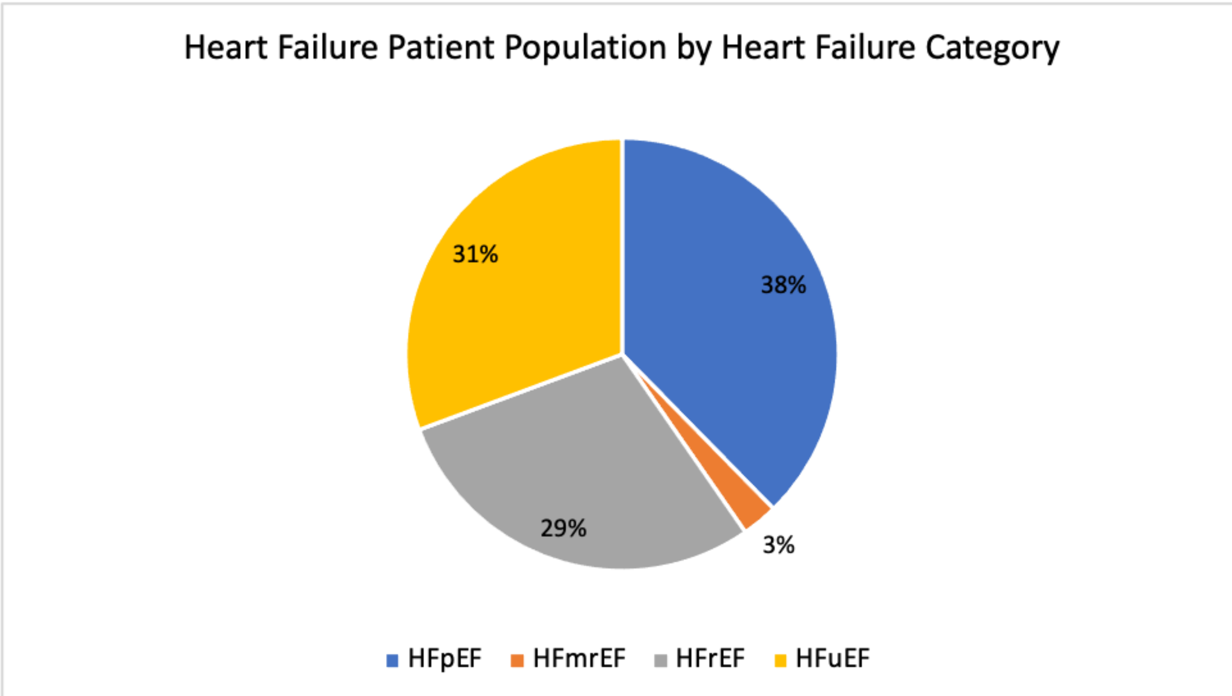
	Influenza Vaccine	P Value	Pneumococcal Vaccine	P Value	COVID-19 Vaccine	P Value
Heart Failure Category						
HFpEF	1749 (63%)	<0.01	2288 (83%)	<0.01	2382 (86%)	<0.01
HFmrEF	129 (65%)		139 (70%)		175 (88%)	
HFrEF	1075 (51%)		1450 (68%)		1683 (79%)	
HFuEF	1048 (47%)		1606 (71%)		1730 (77%)	
Gender						
Female	1823 (55%)	0.1824	2483 (75%)	0.2008	2680 (81%)	0.8893
Male	2178 (54%)		3000 (74%)		3290 (81%)	
Age						
<65	755 (40%)	<0.01	1010 (54%)	<0.01	1365 (73%)	<0.01
≥65	3246 (59%)		4473 (82%)		4605 (84%)	
Race/Ethnicity						
Asian	316 (59%)	<0.01	425 (79%)	<0.01	451 (84%)	<0.01
Black	363 (48%)		554 (73%)		589 (78%)	
Hispanic	521 (52%)		754 (76%)		791 (79%)	
White	2283 (59%)		3023 (78%)		3263 (84%)	
Other	518 (44%)		727 (62%)		876 (75%)	
Language						
English	3630 (56%)	<0.01	4889 (75%)	0.4036	5359 (82%)	<0.01
Non-English	371 (46%)		594 (73%)		611 (76%)	
ACO Status						
Member	1197 (72%)	<0.01	1464 (88%)	<0.01	1529 (92%)	<0.01
Non-Member	2804 (49%)		4019 (71%)		4441 (78%)	
Insurance						
Commercial	503 (43%)	<0.01	615 (53%)	<0.01	925 (79%)	<0.01
Medicaid	151 (33%)		250 (54%)		284 (62%)	
Medicare	2793 (58%)		3918 (81%)		4027 (83%)	
Managed Care	511 (76%)		580 (86%)		624 (93%)	
Other	43 (23%)		120 (63%)		110 (58%)	
SVI						
High risk >90	163 (43%)	<0.01	267 (70%)	<0.01	262 (69%)	<0.01
Medium risk 50 to 90	880 (47%)		1311 (70%)		1437 (77%)	
Low risk <50	2866 (59%)		3732 (77%)		4110 (85%)	
Risk unknown	92 (36%)		173 (67%		161 (62%)	
Provider Type						
Primary care provider	2989 (67%)	<0.01	3668 (83%)	<0.01	3992 (89%)	<0.01
Cardiology provider	2501 (65%)		2987 (77%)		3417 (88%)	
Both providers	1953 (73%)		2243 (84%)		2459 (92%)	
Non-UCLA provider	464 (27%)		1071 (62%)		1090 (63%)	

Table 3. Odds of Vaccination Among Heart Failure Patients by Heart Failure Category, Patient Factors, and Provider Factors

Predictors	**Influenza Vaccine**		**Pneumococcal Vaccine**		**COVID-19 Vaccine**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Heart Failure Category (reference: heart failure unspecified EF)						
Heart failure preserved EF (≥50)	1.36**	1.20-1.54	1.32**	1.14-1.53	1.27**	1.09-1.49
Heart failure mid-range EF (41-49%)	1.41*	1.02-1.96	0.77	0.55-1.10	1.35	0.86-2.22
Heart failure reduced EF (≤40%)	1.00	0.88-1.14	0.81**	0.71-0.94	0.95	0.81-1.11
Patient Factors						
Male gender	1.06	0.96-1.18	1.26**	1.12-1.42	1.10	0.97-1.26
Age ≥65 years	1.58**	1.28-1.95	3.22**	2.59-4.02	1.43**	1.11-1.84
Race/ethnicity (reference: White)						
Asian	1.23*	1.00-1.51	1.39**	1.09-1.79	1.22	0.94-1.60
Black	0.74**	0.62-0.89	1.00	0.81-1.22	0.9	0.72-1.12
Hispanic	1.22*	1.03-1.46	1.50**	1.23-1.84	1.26*	1.02-1.57
Other	0.78**	0.67-0.91	0.62**	0.53-0.72	0.82*	0.69-0.97
Non-English speaking	0.65**	0.55-0.78	0.82*	0.67-0.99	0.69**	0.56-0.85
ACO Member	1.43**	1.25-1.65	1.73**	1.45-2.09	1.92**	1.55-2.38
Insurance type (reference: Commercial)						
Medicaid	0.99	0.77-1.26	1.54**	1.21-1.95	0.59**	0.46-0.76
Medicare	1.48**	1.15-1.91	3.00**	2.31-3.91	0.85	0.64-1.13
Managed Care	2.11**	1.65-2.71	2.31**	1.74-3.07	1.81**	1.26-2.63
Other	0.40**	0.27-0.58	1.27	0.90-1.81	0.40**	0.28-0.57
Age ≥65 years*Medicare	0.86	0.63-1.17	0.52**	0.37-0.71	1.14	0.80-1.62
SVI (reference: low risk <50)						
High risk (>90)	0.84	0.66-1.08	1.03	0.79-1.34	0.62**	0.47-0.80
Medium risk (50 to 90)	0.79**	0.70-0.90	0.88	0.77-1.02	0.74**	0.64-0.87
Unknown risk	0.51**	0.38-0.67	0.80	0.60-1.07	0.36**	0.28-0.48
Provider Factors (reference: primary care provider)						
Cardiology provider	0.84*	0.72-0.99	0.60**	0.49-0.72	1.32**	1.07-1.63
Both providers	1.79**	1.57-2.05	1.18	0.99-1.40	2.11**	1.74-2.56
Non-UCLA provider	0.34**	0.29-0.40	0.51**	0.43-0.60	0.52**	0.44-0.62

Notes. Three multiple logistic regression models estimating odds of vaccination for influenza, pneumococcal, and COVID-19 vaccines by heart failure category, patient factors, and provider factors. In this analysis, N=7341 represents patients with heart failure from 2019 to 2022 in the UCLA Health Heart Failure Registry. COVID-19= coronavirus disease 2019; EF= ejection fraction; ACO= accountable care organization; PCP= primary care provider; UCLA= University of California, Los Angeles; OR=odds ratio; CI= confidence interval. *Value is significant at the 0.05 level; **Value is significant at the 0.01 level.

Figure 1. Heart failure patient population by heart failure category



Notes: The heart failure patient population of N=7341 is stratified into the following heart failure categories and patient sample: HFpEF=2764, HFmrEF=198, HFrEF=2127, and HFuEF=2252.

Figure 2: Vaccination rates for influenza, pneumococcal, and COVID-19 vaccines by heart failure category

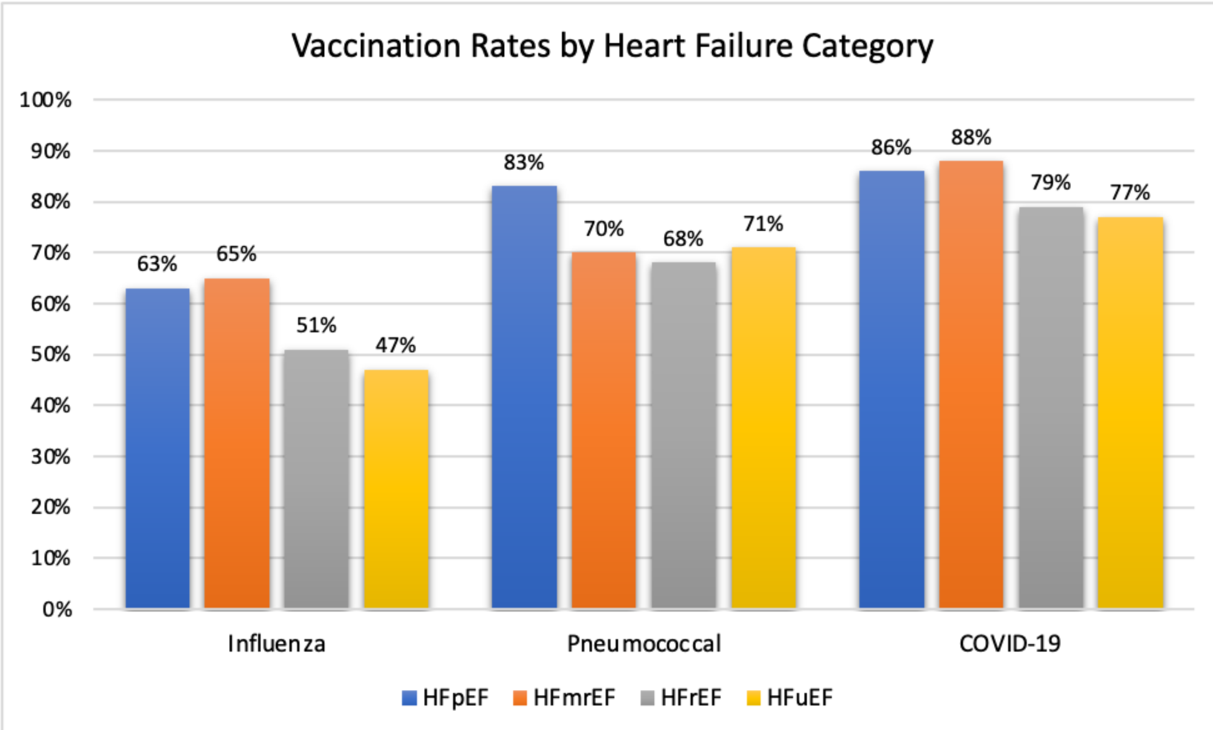
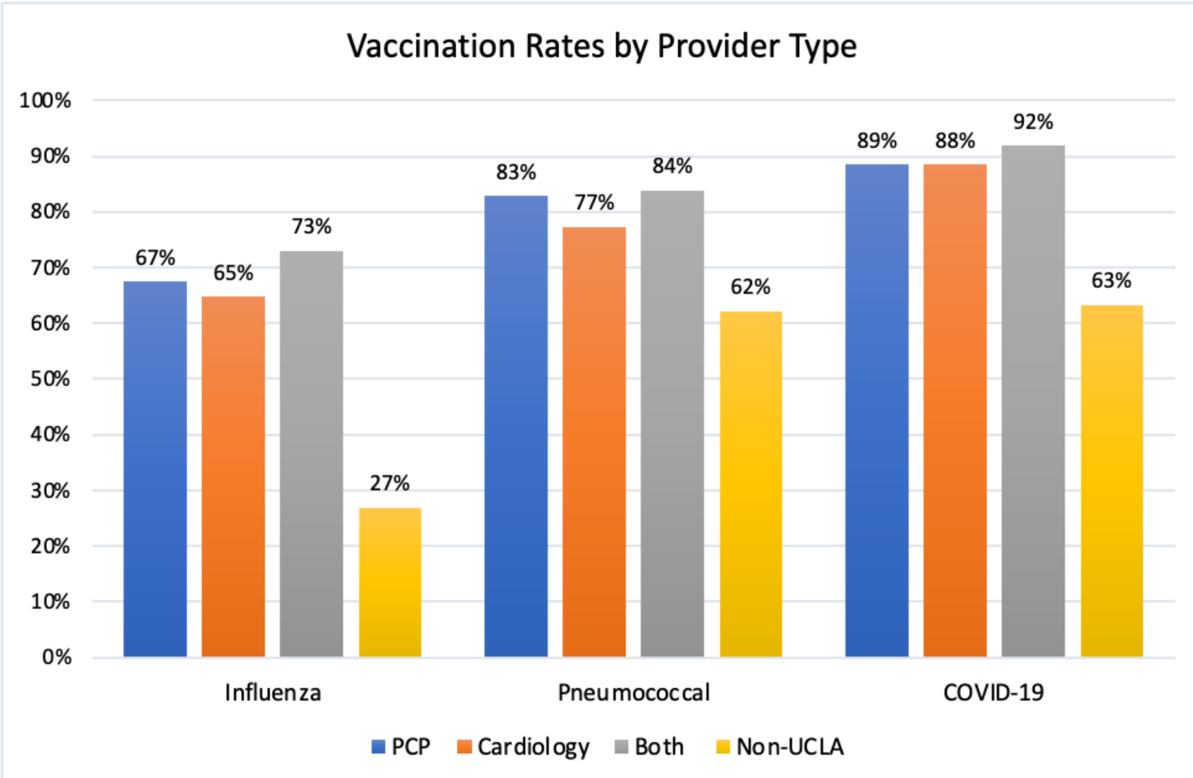


Figure 3. Vaccination rates for influenza, pneumococcal, and COVID-19 vaccines by patient factors (gender, age, race/ethnicity, language, insurance, ACO)

Figure 4. Vaccination rates for influenza, pneumococcal, and COVID-19 vaccines by provider type



Chapter 6: Discussion

There have been very few studies examining the receipt of common respiratory vaccines concurrently among patients with heart failure, especially those including newer COVID-19 vaccines. In this study of adults with heart failure, individuals with more severe heart failure had the lowest levels of respiratory vaccination that could prevent infections and hospitalizations. Patients with preserved and mid-range heart failure had the highest odds of receipt of all three vaccine types, adjusting for demographic and social factors. Vaccination rates for the three vaccines were comparable to the general public [13, 67], but there were significant gaps in vaccination for patients with reduced heart failure who could benefit most from this preventive intervention.

Of the three respiratory vaccines, the vaccination rates were the lowest in the influenza vaccine (54.5%). The influenza vaccine has been available since 1945, but the public interest in receiving this vaccine is low. A 2021 survey found that in the general US public, only 56% (N=631) of adults wanted to receive an influenza vaccine, and among those who were unsure, 39% did not believe flu vaccines worked very well [69]. However, survey participants also believed that healthcare providers were the primary and most trusted source of information about influenza and influenza vaccination. The CDC recommends assessing the vaccination status of patients and addressing misconceptions about vaccines at all clinical encounters [70]. A best practice recommendation is to incorporate education on preventive practices like annual flu shots as part of patient self-management, especially for patients with more severe heart failure.

Pneumococcal pneumonia infections are one of the leading causes of heart failure admissions to hospitals [36, 37]. In this study, patients with reduced ejection fraction heart failure had the lowest levels of pneumococcal vaccination and lower odds of vaccination than other heart failure types. These findings align with prior studies that have found a high incidence of pneumonia among patients with heart failure, even those with preserved ejection fraction heart failure [71]. Meta-analyses have also found that in the general adult population, pneumococcal vaccination is associated with a decreased risk of cardiovascular events and myocardial infarction in all age groups [40]. Since much of the clinical management of patients with preserved heart failure is primarily directed toward treating associated conditions [20], vaccination in this population may produce more favorable outcomes.

Underlying heart disease is associated with an increased risk for in-hospital death among patients hospitalized with COVID-19 [44]. Of the three vaccines in this study, the vaccination rates were the highest for the COVID-19 vaccine (81.3%). At the beginning of the COVID-19 pandemic, there was a great deal of media attention to COVID-19 hospitalization and mortality rates for those with high-risk medical conditions, and initially, COVID-19 vaccines became available earlier for individuals with high-risk medical conditions, including heart failure. Efforts to increase COVID-19 vaccination in this population may explain why COVID-19 vaccination levels were high in the sample. However, there were still significant vaccination differences among the four heart failure categories, with those with reduced or unspecified ejection heart failure having the lowest levels of COVID-19 vaccination. As such, there is a need for targeted communication and outreach to patients with more severe types of heart failure.

Patient Factors

Identifying heart failure as systolic (reduced heart failure), diastolic (preserved heart failure), or mid-range is critical for the clinical management of this patient population [20, 21]. In this study, the largest heart failure population was patients with preserved ejection fraction (38%). Mid-range heart failure had the lowest population count (3%). The literature shows that mid-range heart failure category was only created in 2016 and is not yet well recognized. As discussed above, both preserved and mid-range heart failure had the highest vaccination rates in all three vaccine groups, while reduced and unspecified heart failure had the lowest. Reduced heart failure is usually managed by cardiologists who focus on heart failure medication titration than closing preventive care gaps. This could be one of the reasons that influenza and pneumococcal rates were low in cardiology-only providers. However, due to the public health approach to vaccinating high-risk cardiac patients for COVID-19, vaccination rates were high for cardiology. In addition, patients with reduced heart failure tend to have multiple comorbidities and spend most of their clinic visits on acute problems arising from their medical conditions. There is limited time to address preventive care gaps with their cardiologists. More vaccination resources need to be directed to the reduced heart failure population, as they are at the highest risk of being admitted and readmitted to the hospital with respiratory infections.

The literature shows that men have a higher incidence of heart failure. However, the overall prevalence rate is similar in both genders since women survive long after the onset of heart failure [3]. Women tend to be older when diagnosed with heart failure and more often have diastolic dysfunction (preserved heart failure) than men [3]. In this study, 55% of the population were male, and 36% (N=1477) had reduced heart failure diagnosis. In the female population, the top diagnosis was diastolic (preserved) heart failure (47%). There were no gender differences seen in the vaccination outcomes, except in the pneumococcal vaccine. Male patients had 1.26 higher odds of getting the pneumococcal vaccine than female patients.

There were age differences in vaccine outcomes. Patients 65 years and older had 1.58 odds of getting the influenza vaccine, 3.22 odds of getting the pneumococcal vaccine, and 1.43 odds of getting the COVID-19 vaccine as compared to patients under 65. Patients under 65 had significantly lower vaccination rates in all vaccine types (influenza 40% vs. 59%, pneumococcal 54% vs. 82%, COVID-19 73% vs. 84%). Data show that younger adults are experiencing disparities in heart failure care compared with older adults [18]. Over the past decade, death rates for adults between 35 and 64 with heart failure have increased [3]. Earlier publications have established that vaccination uptake is low among patients under 65 [26]. There are various reasons why younger people hesitate to get the vaccine, such as fear of side effects, a sense of invincibility, and a lack of adequate information to make informed decisions. Healthcare providers can address these issues during clinic visits and intervene by educating patients on vaccine recommendations for all age groups.

Racial disparities in heart failure and cardiovascular disease, in general, are well documented. Non-Hispanic Black individuals, those without health insurance, and those with diminished access to healthcare services have the lowest vaccination rates [18, 72]. In this study, patients identified as White or Asian had the highest vaccination rates in all three vaccines, followed by Hispanics. Patients identified as Black, or the "Other" race category had the lowest vaccine rates. There is a need to restructure health systems to deliver optimal care to all patients and target resources to those with the highest need. In addition, targeted vaccine communication to address the concerns of minorities could help with vaccine hesitancy. Different from other studies is the finding that patients identified as Hispanics had higher odds (OR 1.22-1.50) of getting vaccinated than Whites in all three vaccine outcomes. Further exploration of this area can be helpful since Los Angeles has one of the highest Hispanic populations, and insights on best practices can be adapted to other populations and geographic regions.

In this study, 11% (N=809) of the patient population identified another primary language other than English. These patients had lower odds of getting vaccinated (OR 0.65-0.82). Past studies have found that not speaking English as a primary language is associated with suboptimal health care in the U.S., where about 9% of the population is classified as limited English proficiency [3, 18]. As this study demonstrates, some of the disparities seen in heart failure can be fueled in part by language barriers between patients and providers. Utilizing interpreter services in inpatient and outpatient settings is key in getting the patient information in their own language. Including an interpreter can take some planning, but the long-term benefits for patients outweigh the time spent on the activity.

There were insurance differences in vaccine outcomes. The majority of the patients (66%, N=4851) in this study had Medicare insurance, with 58% vaccinated for influenza (the general influenza vaccine rate was 55%). Pneumococcal and COVID vaccinations were also some of the highest in all insurance categories (81% and 83%, respectively). However, the highest vaccination rates for all three vaccines were in the managed care and accountable care organization groups. Being part of managed care increased the odds of being vaccinated compared to commercial insurance. It was similar for patients who were part of an accountable care organization. Patients in these types of networks get targeted patient education and annual reminders about their preventive care overdue items. In contrast, patients with Medicaid had some of the lowest vaccine rates. Compared to commercial insurance, they had lower odds of getting influenza and COVID-91vaccines but higher odds of getting the pneumococcal vaccine. These findings could highlight differences in insurance policies regarding vaccine coverage. Affordable Care Act requires vaccine coverage by health insurance. Still, some plans have copays and only cover vaccines given at the physician's office or a limited set of locations. Broader guidelines and policy changes are needed to increase vaccine access and affordability.

The Social Vulnerability Index (SVI) measures the potential negative effects on communities caused by external stresses, including natural or human-caused disasters or disease outbreaks on human health. The higher the score, the higher the vulnerability. At UCLA Health, a physical address is used to map the SVI score. However, not all addresses are mapped to the Census Tract in California due to being in an isolated geographical location. Therefore, a small sample of patients (3.5%, N=259) are categorized as unknown. Of the total population, 5.2% (N=381) were classified as high risk (score >90), and 25.5% (N=1875) were classified as medium risk (scores between 50 to 90). Compared to low risk (score <50), high and medium risk had lower vaccination rates. Patients with high risk and medium risk had lower odds of getting the COVID-19 vaccine. Patients with medium risk also had lower odds of getting the influenza vaccine. These findings highlight the importance of considering social vulnerability index in intervention design and resource allocation.

Provider Factors

The study results highlight the varying practice trends in heart failure vaccination outcomes between primary care, cardiology, both providers, and no primary care or cardiology provider registered in the health system. In the unadjusted data, cardiology providers had comparable vaccination rates with primary care providers. In the adjusted models, the analysis included primary care and cardiology by itself (i.e., no co-management). Patients who had primary care provider had better vaccination rates. Patients with both primary care and cardiology providers had the highest vaccination rates in all vaccine categories. Compared to primary care provider only, both providers increased the odds of being vaccinated for influenza (OR 1.79) and COVID-19 (OR 2.22). This data supports patients benefit from having both primary care and cardiology providers. Implementing a team-based approach can improve vaccination rates and the care of patients with heart failure.

Patients with no primary care or cardiology provider registered in the health system (N=1723) had the lowest vaccination rates of all the provider types. Since vaccine data includes external and internal immunization records from the California Immunization Registry (CAIR2) and Epic Care Everywhere, the potential for missing vaccine data is low. Additionally, no significant differences are seen when comparing no primary care or cardiology provider with having a primary care or cardiology provider on sociodemographic variables available in the dataset. However, there might be other important variables that are not captured in the dataset. Some patients only come to UCLA Health for tertiary or quaternary level of care. One of the strategies the health system is focused on is to help patients establish a primary care provider within the system (if needed) before they are sent home from the hospital.

Health System Design

Implementing one-off interventions can help some groups of patients, but what is needed is a multipronged systems approach to improve the health of the entire population and reduce health inequities among all population groups. The Chronic Care Model provides a framework for structural change at the health system level that can be used for chronic disease management. Focusing on the four key areas of health system redesign (i.e., self-management support, delivery system design, decisions support, and clinical information system) can create the improvements we need to support care teams in delivering the best possible care to their patients.

Designing robust data systems to understand and track a complex population like heart failure can create structure, process, and outcomes to improve the health of the population. The recent build of the heart failure registry allows stakeholders to understand gaps in the population and identify areas for improvement. The registry feeds the process and outcome measures, including vaccine status, into the cardiology and heart failure dashboards. The dashboards provide real-time data with scorecards that show performance in guideline-directed medical therapy (GDMT) measures to facilitate evidence-based care delivery. Using the dashboard, providers can visualize their performance for each quality measure and see the current performance of the entire division. As seen with the IMPROVE-HF national registry, data transparency over time can improve the use of GDMT in eligible patients in outpatient clinics [20]. In the future, vaccine measures can also be included in the current primary care and cardiology incentive programs that provide individual clinicians financial incentives for quality efforts in closing care gaps.

Optimizing tools in the electronic health record (EHR) can also support providers in delivering high-quality care. Some focus areas in the EHR include providing clinical alerts and reminders such as adding specific heart failure diagnoses on the problem list, enabling evidence-based decisions at the point of care such as ordering a guideline-recommended medication that is missing from the patient's profile, and aggregating patient data that assists with decision support.

Primary care providers utilize the Health Maintenance section in the EHR to track vaccination status and routine screening tests to manage patients with chronic diseases. Other providers and care team members can also check for upcoming preventive health tests and procedures. The Care Gaps SmartSet helps primary care providers manage the care gaps topics in the Health Maintenance module. This SmartSet contains the most common orders in one convenient place, and it is designed to dynamically reflect the missing health maintenance items for individual patients. Building a similar workflow process for cardiology providers can also assist them in using tools to close care gaps.

Starting this year, the first-ever specialty module is being built in EPIC, and it will be for the cardiology providers at UCLA Health. The module will include guideline-recommended heart failure medications, including angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARB), angiotensin receptor-neprilysin inhibitors (ARNIs), aldosterone antagonists (MRA), beta blockers, hydralazine and isosorbide for self-identified as Black or African American, Sodium-glucose Cotransporter-2 [SGLT2] inhibitors, aspirin, and antiplatelet therapy, statin, and the three respiratory vaccines. Once the module is up and running, the heart failure measures will also be shared with primary care providers to increase the use of heart failure guideline-recommended therapies. Making tools available for both providers will improve performance in all quality indicators.

In addition to impacting health system structures, it is important to engage patients in updating their medical records by filling out questionnaires about their sociodemographic, quality of life, and clinical measures through the patient portal. Patients receive better care when care teams have access to complete and accurate information on their medical records. Even more importantly, giving access to patients to view their Health Maintenance topics provides them a summary of all their preventive care items, including overdue items they need to address. Patient engagement is critical in making improvements in heart failure outcomes.

Limitations

There are strengths and limitations to this study to consider in interpreting the findings. Our study used a large, population-based sample of adults with heart failure derived from a comprehensive heart failure patient registry. Validity testing of the registry data was conducted by a team of primary care and cardiology providers, quality specialists, and computer programmers and analysts during a six-month period to establish a high level of sensitivity and specificity. However, a provider had to actively include heart failure on the EHR's problem list for the patient to be counted in the registry and thus it is possible that the registry does not capture all patients in the health system with heart failure. We had complete vaccine outcomes data pulled from multiple sources, including CAIR2 and Epic Care Everywhere. However, our study did not capture patients who received Prevnar 20 for the pneumococcal vaccine, which was added to the health system EHR after the time of the study. In addition, the COVID-19 boosters were not counted for numerator compliance. At the time of the study, hospitalization and mortality data were unavailable for the patient population. In addition, vaccination status in relation to GDMT compliance was not measured. Despite these limitations, our findings can inform ways to implement population-level interventions to improve vaccination outcomes among patients with heart failure.

Conclusion

Heart failure is a complex chronic disease to manage, but preventive care practices like vaccinations can improve patient outcomes and reduce the risk of infections, hospitalization, and mortality. There is a need for ongoing research and discovery. The study findings from this research provide insights into patient and provider factors associated with respiratory vaccination outcomes. These findings can help identify strategies that can improve the equitable and optimal implementation of vaccines in ambulatory care practices.

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