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Sociodemographic Determinants of Potentially Avoidable Hospitalizations due to Ambulatory Care Sensitive Conditions Among Hospitalized Patients in the United States

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Abstract

Social determinants of health play a crucial role in explaining the variation of potentially avoidable hospitalizations (PAH) due to Ambulatory Care Sensitive Conditions (ACSCs). Utilizing data from the National Inpatient Sample from 2018 to 2020 in the United States, this study conducted retrospective cohort analyses to explore the relationships between sociodemographic factors, specifically income, race, geography, age, and sex and PAH. Our approach used multilevel logistic regression models to adjust for potential confounders and account for clustering of admissions within hospitals. Of the 17,629,891 hospital admissions examined in this study, 1,868,609 (10.6%) were attributable to ACSCs. Our results indicate that individuals of black or Hispanic ethnicity, lower income groups, and people living in the southern region had higher admissions due to ACSCs. These associations were consistent when evaluating individual ACSCs, being more pronounced for chronic conditions. This study highlights the need for focused policy interventions and healthcare strategies aimed at reducing these disparities.

Keywords

Potentially avoidable hospitalization, ambulatory care sensitive conditions, social determinants of health, ACSC hospitalization

Summary for Lay Audience

The trend of increasing healthcare expenditures in the United States is a growing concern. A significant part of these costs is attributed to avoidable hospital stays due to Ambulatory Care Sensitive Conditions (ACSCs). These are cases where appropriate and timely outpatient primary care could prevent the need for hospital admissions. Research has shown that social determinants of health (SDH) significantly influence variations in these hospital admissions. These disparities are linked to various factors, including poverty, unemployment, education levels, and health insurance access. However, the limited breadth of representation in these studies highlights a crucial gap, necessitating further investigation with more inclusive and diverse data sets to fully understand and address these health inequities.

Our current study addresses these gaps by utilizing a nationally representative database to investigate how race, income, geography, age, and sex correlate with potentially avoidable hospitalizations (PAH) due to ACSCs among hospitalized patients in the US from 2018 to 2020. Employing comprehensive biostatistical methods, we analyzed these relationships, taking into account the influence of various individual-level and hospital-level characteristics. We found that Black and Hispanic patients, those with lower socioeconomic status, and individuals residing in the South were more likely to have in-hospital admissions due to ACSCs. This pattern persisted across individual ACSCs and their relationship with SDH. By examining the link between SDH and PAH, we gain insights into the distribution of adverse health outcomes across different demographic groups in the US. Our findings provide valuable guidance for the development of targeted policy interventions and healthcare strategies aimed at addressing these disparities and advancing health equity.

Co-Authorship Statement

Munira Kashem, Dr. Shehzad Ali, and Dr. Pallav Garg were responsible for study conception, design, and the statistical analysis plan. Munira Kashem was involved in coding, data cleaning, performing the data analysis, interpreting the findings, and writing the papers. Drs. Shehzad Ali, and Pallav Garg were involved in the interpretation of the data and critical revision of the papers. All authors contributed to editing the thesis and granted final approval for its submission.

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List of Abbreviations and Acronyms

ACSCs	Ambulatory Care Sensitive Conditions
PAH	Potentially Avoidable Hospitalizations
SDH	Social Determinants of Health
AHRQ	Agency for Healthcare Research and Quality
HCUP	Healthcare Cost and Utilization Project
NIS	National (Nationwide) Inpatient Sample
US	United States
OR	Odds Ratio
CI	Confidence Interval
SD	Standard Deviation
IQR	Interquartile Range
ICD-10-CM	International Classification of Diseases, Tenth Revision, Clinical Modification
ICD-10-PCS	International Classification of Diseases, Tenth Revision, Procedure Coding
BIPOC	Black, Indigenous, and People of Color
COPD	Chronic Obstructive Pulmonary Disease
UTI	Urinary Tract Infection
CAP	Community Acquired Pneumonia
CHF	Congestive Heart Failure

Chapter 1

1 Thesis Introduction, Rationale, Objectives, and Organization

In this chapter, a foundation is established, explaining the rationale for the thesis. It discusses the central aim and research objectives of the study and concludes by detailing the thesis's organizational framework.

1.1.1 Background

In the United States, healthcare expenditure has consistently outpaced economic growth, with current trends showing a persistent increase in hospital spending (1,2). A significant factor in these rising costs is potentially avoidable hospitalizations (PAH), also referred to as Ambulatory Care Sensitive Conditions (ACSCs). ACSCs are the conditions for which proper and timely care in an outpatient setting can prevent the need for hospital admission (3,4). These avoidable admissions burden hospital resources and significantly inflate healthcare expenditures (5,6). In 2017, PAH accounted for an estimated $34 billion in the US in healthcare costs, highlighting their substantial economic impact (7).

Simultaneously, social determinants of health (SDH) - including social, economic, and political factors - significantly influence health service utilization and outcomes (8,9). Disparities are evident across various SDH indicators, including race/ethnicity, poverty, unemployment, educational attainment, and access to health insurance (10-12). Addressing these determinants is crucial for improving health outcomes and mitigating health inequities (13, 14). Understanding SDH is imperative for interpreting the trends of PAH and identifying the factors that contribute to health inequities.

1.2 Thesis rationale

Prior studies have reported higher likelihood of experiencing PAH among people from minority racial groups with low socioeconomic status (15-20). Research also suggests that hospitals in the South experience higher rates of PAH, while those in the West report

lower rates (21,22). Furthermore, significant associations between socioeconomic factors and chronic ACSCs have been established (16,23-26). However, these studies are constrained in their scope. Research exploring the association between sociodemographic factors and PAH, as well as individual ACSC often restricts their sample selection based on criteria such as age (15,27), a single ACSC (23,24), an isolated sociodemographic factor (28,29), a specific geographical region (15,27) or a distinct racial group (17). Furthermore, prior investigations have relied on data sourced from considerably earlier periods (16,98,153). A recent study investigating variations in rates of ACSCs utilized data from only a single year (18). The present research aims to examine the associations between sociodemographic factors and potentially avoidable hospitalizations (PAH). Utilizing a comprehensive and contemporary dataset, it aims to broaden current understanding and address gaps in the literature concerning these factors' impact on PAH.

1.3 Objective

Specifically, this thesis has two research objectives:

1) To examine the association between PAH and race, socioeconomic status (SES), geographic location, age, and sex among adult hospitalized patients while controlling for potential confounders; and

2) To evaluate the association between each type of Ambulatory Care Sensitive Condition (ACSC) and race, socioeconomic status (SES) and geographic location among adult hospitalized patients while controlling for potential confounders.

1.4 Structure

Chapter 2: This chapter presents a review of the existing literature, providing the foundational basis and justification for the analyses undertaken in this thesis.

Chapter 3: This chapter aims to evaluate the association of sociodemographic factors with potentially avoidable hospitalizations among hospitalized patients of ≥18 years in the US.

Chapter 4: This chapter aims to evaluate the association of race, socioeconomic status (SES), and geographic location with each type of Ambulatory Care Sensitive Condition among hospitalized patients of ≥18 years in the US.

Chapter 5: This chapter discusses the limitations of the studies undertaken in this thesis, offers concluding remarks, and suggests potential directions for future research.

Chapter 2

2 Literature Review

In this chapter, the thesis topic is introduced through a literature review on potentially avoidable hospitalizations (PAH). This chapter discusses various associational factors of PAH and its impact on both patients and the healthcare system. Additionally, the chapter delves into the role of social determinants of health (SDH) and how they influence access to healthcare. It concludes by reviewing existing studies related to the specific SDH examined in this thesis, particularly in relation to PAH.

2.1 Potentially Avoidable Hospitalization

2.1.1 Definition

Potentially avoidable hospitalizations (PAH) can be understood as health conditions that may not require hospital admission if timely and effective outpatient care is available (3,4). Outpatient care comprises primary care, ambulatory surgical care, and urgent care, delivered in physicians' clinics, community health centers, or outside hospital emergency department settings (236). PAH are also referred to as hospitalizations due to ambulatory care sensitive conditions (ACSCs) or ACSCs hospitalizations. However, agreement on adopting a single list of ACSCs has remained elusive due to the fact that the criteria are influenced by the scope of health care services and the particular setting where the indicator is applied (30,31). Hence, multiple lists are commonly used in research, leading to considerable variation in identification of ACSCs.

One common approach in identifying ACSC observed is through a consensus method, often using the Delphi or modified Delphi method with a panel composed of experts (4,32-36). Additionally, the definitions set by Purdy et al., which encompass 36 conditions, are often utilized either as an independent guide or as a foundational framework combined with other context-specific conditions (18,37-40). Concurrently, a list of ACSC by the Agency for Healthcare Research and Quality (AHRQ) is widely acknowledged and applied in research (41-45). There are also alternative definitions in use. For instance, some studies adopt the Canadian Institute for Health Information

(CIHI) definition (46-48) or the National Health Service (NHS) definition in the UK (49,50). Others even employ multiple methods to delineate ACSC (51,52).

For the purposes of our analysis, we have chosen to follow the AHRQ's evidence-based criteria, which categorizes ACSCs into 10 diseases affecting individuals aged ≥ 18 years. Based on the AHRQ-PQI 2022 guidelines, acute conditions are identified as 1) community-acquired pneumonia and 2) urinary tract infection. Chronic conditions include 1) short-term complications of diabetes; 2) long-term complications of diabetes; 3) chronic obstructive pulmonary disease (COPD) or asthma in older individuals; 4) hypertension; 5) heart failure; 6) uncontrolled diabetes; 7) asthma in younger adults; and 8) lower-extremity amputation among diabetes patients. This definition explicitly omits obstetric admissions, transfers from other facilities, certain procedure codes, and hospitalizations lacking crucial patient data like sex, year of hospitalization, main diagnosis, or residence (53).

The AHRQ definitions are widely regarded as reliable and valid. Their robustness is confirmed through meticulous assessments based on criteria such as face validity, precision, minimal bias, construct validity, potential for true quality improvement, and prior application (54). A study by Pinto et al.,2020 further corroborates the superior reliability of AHRQ definitions than the CIHI definitions; it showed similar rates of avoidable hospitalizations and consistent trends over time when compared with the Delphi method employed by Sarmento et al. (55).

2.1.2 Causes of ACSCs

While limited access to primary health care is universally acknowledged as the fundamental cause for ACSCs hospitalizations (3), a myriad of additional factors contributes to barriers in accessing these services. Existing literature extensively documents a range of underlying causes. Several studies have reported nonadherence to prescribed medications (51,56-58), lack of available social resources such as transportation and caregiver support (7,51,56-59), insufficiency in physician supply (56,60,61), cultural or language barriers (51,58,62,63) as common obstacles in utilization of ambulatory care. Additional factors include challenges in accessing health services outside of regular working hours (51,57,58), a general lack of health-related knowledge

(57,58), patient attitudes like illness avoidance or denial, sometimes exacerbated by social stigmas (51,57,64). Furthermore, communication gaps are another significant barrier. These gaps are evident in interactions between primary care providers and specialist physicians (65), as well as between healthcare providers and patients (57,58). Other factors include the absence of medical insurance coverage (58,66), financial constraint (58), and cognitive impairment or substance abuse (51, 57).

2.1.3 Economic burden on healthcare system

The trajectory of healthcare spending in the U.S. has been on a consistent rise, outpacing the growth of the overall economy since the 1960s (67). When evaluated both on a per capita basis and as a proportion of the Gross Domestic Product (GDP), this spending remains significantly higher in the United States than in other high-income countries (1). In the year 2021, a 2.7% increment in national healthcare expenditures was observed, reaching a total of $4.3 trillion. This translates to an average of about $12,900 per person, representing 18.3% of the country's GDP (2,68). A closer examination of these figures reveals that the expenditure on hospital care alone constituted around 31% of the overall healthcare spending (68). Although there was a deceleration in the growth rate of hospital spending from 6.2% in 2020 to 4.4% in 2021, the trend of rising costs continues steadily each year, with a notable portion being potentially avoidable (2).

Given the inherent complexity of care within inpatient settings, costs tend to be consistently high. An analysis of data from 2005 to 2010 revealed that charges for inpatient visits due to ACSCs were fourfold compared to those for emergency department (ED) visits, and ACSC visits to the ED incurred charges that were double the charges for those managed in outpatient hospital-based clinics (69). Additionally, there is evidence indicating a substantial contribution of ACSCs hospitalizations to healthcare expenditures relative to non-ACSCs hospitalizations. In an analysis of hospitalization data from Medicaid enrollees, it was found that the mean hospital expenditures for the ACSCs group were significantly higher, amounting to $18,070, as compared to the non-ACSCs group which reported expenditures of $14,452 (70).

Many prior studies have explored the rise in hospital costs, especially attributing this increase to potentially avoidable circumstances among elderly individuals (>65 years). An analysis of the 2012 to 2016 NIS data focusing on older adults found that the total annual hospital expenditures resulting from hospitalizations for preventable conditions and its complications surpassed $10 billion (71). Another study, specifically focusing on centenarian individuals, indicated that the total national charges for hospitalizations during the period from 2000 to 2009 totaled $116 billion, with $34.2 billion attributable to potentially avoidable hospitalizations (72). In addition to discussing hospital expenditures for all ACSCs admissions collectively, examining each condition separately can enhance our comprehension.

2.1.3.1 PAH due to congestive heart failure

CHF has been one of the most common reasons of avoidable hospitalizations in the United States (7,73). According to HCUP statistical briefs, in 2017, CHF emerged as the most expensive reason for potentially avoidable in-hospital stays, accounting for an accumulative hospital cost of $11.2 billion (7). This amount represented 33.2% of the total costs of admissions attributable to all ACSCs (7). A systematic review of studies reporting costs or charges per hospital admission for CHF in the US published between 2014 and 2019 underscored the significant economic burden posed by hospitalizations for CHF, with the mean inpatient costs ranging from $10,737 to $17,830 per hospitalization (74). Greene et al. 2020 suggested that a substantial portion of CHF admissions, primarily requiring aggressive IV diuresis, might be treated as outpatients, potentially saving billions (75). Zilberberg et al. supported that by displaying nearly one-half of all short-stay hospitalizations for CHF as a primary diagnosis are of low severity and can be effectively managed in the outpatient department (76).

2.1.3.2 PAH due to diabetes and related complications

Managing diabetes can be costly due to its chronic nature and the complications (77). Several studies have highlighted hospital expenditures attributed to such conditions. HCUP statistical briefs reported that in 2017, diabetes constituted $7.4 billion (22%) of the total costs associated with PAH due to all ACSCs (7). A study using NIS 2017 data

focusing solely on diabetic ketoacidosis found that the adjusted hospital charges increased from $5.28 billion in 2014 to $6.76 billion in 2017 (79). Uncontrolled diabetes was examined by a study using data from National Hospital Discharge Survey (NHDS) dataset and it showed that hospital costs for admissions due to this condition were about $2.4 billion (5). Shrestha et al., 2019 also demonstrated that there was a nearly 2% yearly increase in costs for avoidable diabetes-related hospital stays between 2001 and 2014 (80).

2.1.3.3 PAH due to hypertension

In a study from 2005 to 2012 on in-patient stays due to hypertension estimated the expenditure amounting to around $41 billion over these 8 years (81). Authors also showed that, the expenses were four times more for those who were adherent to medications than the poor adherers. Additionally, a study conducted from 1979 to 2006 showed that the adjusted annual costs of hypertension related hospitalizations nearly tripled over this 28-year span (82). It is important to emphasize that, many of these studies did not report the estimates based on hypertension as the principal diagnosis of hospital admissions, but rather reported them in a more general context.

2.1.3.4 PAH due to Chronic Obstructive Pulmonary Disease

Direct costs due to COPD were estimated by prior studies. It has been observed that significant proportion of total direct costs were attributed to hospitalization costs followed by drug acquisition costs, costs for clinic visits, and diagnostic tests (83). A systematic review of studies published until 2019 examined the economic burden of COPD and reported annual per-patient costs. For inpatient stays, costs ranged from $3,826 to $12,046 between 2003 and 2015. In contrast, outpatient visit costs for 2006, 2009, 2010, and 2014 ranged from $883 to $1,869 (84). Another systematic review on studies since 1995 to 2005 also highlighted estimates for the annual per-patient direct costs to be in the range of $2,700–$5,900 and the annual direct costs to be approximately $20–26 billion (85). Additionally, the cost of care is associated with severity of COPD, the costs increase as the severity progresses (83,86). Data indicates an increase in

inpatient hospitalization costs from $7242 to $20757 as a result of progression from moderate COPD exacerbation to severe COPD exacerbation (84).

2.1.3.5 PAH due to community acquired pneumonia

Analysis of 2006 HCUP-NIS data indicated that out of 4.1 million ACSCs admissions, 0.9 million were attributed to bacterial pneumonia resulting in costs amounting to $7.2 billion (73). These costs, combined with those for heart failure ($8.4 billion), contributed to half of the total hospital expenditure associated with PAH due to all ACSCs (73). Divino et al., 2020 analyzed administrative claims and hospital data, revealing that average per-patient costs for CAP constituted 34% of total all-cause patient costs. Notably, inpatient care represented 94% of CAP-related expenses, emerging as the primary driver of its annual economic burden (87). Supporting this, a North American systematic review found CAP hospitalizations range from $3,000 to $13,000 per event, and outpatient visits cost $130 to $4,500 (88). The predominance of inpatient care in the overall costs was consistent with the conclusions drawn by Divino et al.

2.1.3.6 PAH due to Urinary Tract Infection

A retrospective cohort study analyzing NIS data from 1998 to 2011 to investigate hospitalizations due to UTI revealed that the estimated costs of approximately 400,000 hospitalizations for UTIs in 2011 was $2.8 billion. An average hospitalization with a primary diagnosis of UTI costs $3368 in 2001 and $6424 in 2011 (constant December 2011 dollars) (89). A systematic review conducted by Keating et al. 2014 estimated UTIs' total direct costs at US$1.6 billion, with US$474 million in medical expenses and US$112 to US$172 per episode (90).

2.1.3.7 PAH due to Asthma

A study utilizing data from the 1996 Medical Expenditure Panel Survey discovered that the total expenditures for individuals with asthma reached $30.8 billion (91). Similarly, Bahadori et al. 2009 identified that the most significant portion of direct asthma-related costs was attributed to in-patient hospitalization. This accounted for a substantial 52 to

86% of the overall costs associated with asthma and represented 47 to 67% of the total direct costs incurred (92).

PAH not only impacts the economy but also presents several challenges to healthcare systems, notably by placing significant demands on hospital resources. For instance, a study by Cressman et al., 2023 in the Canadian health context showed that preventing PAH could significantly relieve hospital burdens, potentially saving over 500 bed days annually (6). Furthermore, there's evidence suggesting that managing ACSCs in outpatient settings could reduce both physical and emotional distress for patients of all ages (93,94). This approach may also reduce the occurrence of hospital-induced illnesses, particularly in the vulnerable population (93). Additionally, it has been observed that PAH resulting from ACSCs are linked to a higher probability of patients being readmitted within 30 days (95,96), underscoring the need for effective management strategies.

2.1.4 ACSCs rate as indicator of health system performance

Examining the admission rates for ACSCs can offer insight into key factors affecting an individual's ability to access primary care in a timely and effective manner (97). This indicator has been widely adopted by researchers and policymakers to assess the performance and accessibility of healthcare systems (3,4, 97,98). Furthermore, this metric has been implemented in various countries, including the United States (99), England (100), and Australia (101). Accessible and effective primary care can potentially diminish the risk of hospital admissions due to ACSCs. When an area exhibits a high rate of hospital admissions for ACSCs, it could reflect underlying challenges in healthcare accessibility for its residents. Evidence validates the foundational concept of the ACSC indicator; a lower provision of primary care is associated with increased ACSC admissions (60; 102). A systematic review demonstrated the utility of this indicator for ongoing health service monitoring, identifying primary care access barriers in communities, evaluating interventions to improve primary care access, enhancing system efficiency by exploring alternatives to costly care models, and conducting small area analyses to discern communities with notable primary healthcare access issues (103

2.2.1 ACSCs and Social Determinants of Health

Social determinants of health (SDH) are non-medical factors that have a major impact on people's health, well-being, and quality of life (105). They encompass the environments where people are born, live, work, and age, influenced by factors such as economic and social policies, societal norms, and political systems. (104,105) Examples of SDH include economic status, educational level, sex, race/ethnicity, immigration status, employment stability, working life conditions, early childhood well-being, social inclusivity, housing, basic amenities and the environment, food access and affordability, access to affordable and quality health services, and language skills (11,104,105,106). These socio-demographic factors profoundly affect health and overall well-being at both the individual and population level (11). Since PAH is often measured on the basis of primary care accessibility and quality, the examination of PAH necessitates recognizing that healthcare quality and access constitutes one of the five central domains of the social determinants of health (105). This acknowledgment is founded on the notion that the quality of healthcare is intrinsically connected to the positive outcomes from healthcare service utilization, with healthcare service utilization being contingent upon the accessibility of care (107).

It has been established that the attainment of health equity is fundamentally tied to equitable health services utilization (108). Disparities at the community level in avoidable hospitalizations reflect health inequities, as posited by Ayangunna et al., 2021 (106). Evidence suggests that health inequities often correlate with social advantages and disadvantages, creating a nuanced gradient (109). Prior studies have highlighted the existing inequities among various population groups and geographic locations. A study analyzing health inequality trends from 1935 to 2016 illustrated significant racial/ethnic disparities in the US across various SDH indicators, such as poverty, unemployment, educational attainment, and access to health insurance, with minorities generally facing higher poverty and unemployment rates, lower educational attainment, and less access to health insurance compared to non-Hispanic whites (11). In the context of PAH, Coulon et al. 2015 explored variation in satisfaction with blood pressure among Black neighborhoods and reported an association between neighborhood poverty and decreased satisfaction with blood pressure control (12). These explorations underscore the

significant role of social determinants in understanding health disparities across different socioeconomic, racial, and geographic demographics in the US.

In light of these insights, this thesis proposes that understanding the SDH is essential in explaining patterns of potentially avoidable hospitalizations, and consequently revealing underlying factors contributing to health disparities. Relevant social conditions affecting individual and group variations in health status among hospitalized patients in the US were identified. Based on prior literature, and the data elements available in our selected dataset, we chose race/ethnicity, SES, geography, age, and sex as the SDH to be evaluated among hospitalized patients in the US.

Additionally, our conceptualization of social determinants in PAH resonates with Andersen's Behavioural Model of Health Service Utilization (110). This model proposes a framework to explain the socioeconomic impacts on the accessibility and adoption of health services. Consistent with the principal components of this model's revised version (111), the predisposing factors selected for this thesis include age, sex, race/ethnicity; the factors were present before the onset of a particular illness and indicate a tendency toward more health service use. The enabling factor chosen in our analysis, which is indicative of healthcare access, is neighborhood income. Finally, the need for healthcare reflects both perceived and actual health status as assessed by individuals or healthcare providers. In this study, the assessment of health status was carried out by acknowledging the existence of chronic conditions and utilizing comorbidity scores as a reflection of disease burden.

2.2.1.1 Social determinants in patients with potentially avoidable hospitalizations

This section provides a summary of literature regarding key areas of social determinants related to potentially avoidable hospitalizations.

2.2.1.1.1 Race

In health research, race has traditionally been used as an indicator of genetic diversity among populations, believed to explain variations in health outcomes (112; Ford & Kelly 2005; Ibrahim et al. 2021). However, the concept of race as a biological marker has been

rigorously questioned, with emerging research providing no significant genetic evidence for its use (112,113,114). Contemporary studies increasingly view race as a socio-political construct (114,115). Therefore, this study adopts a perspective of race that reflects societal structures and personal experiences, not biological differences. There is evidence that racial and ethnic minorities tend to receive lower quality of care than non-minorities (116), resulting in overall poor health outcomes.

Studies examining racial influence on potentially avoidable hospitalizations have reported that people who self-identified as Black, Hispanic, and other minority racial groups tend to have higher rates of such hospitalizations than the Whites (15-17). Although, a reduction in racial disparities in avoidable hospitalizations has been observed (117), contemporary studies confirm that the disparity, especially between Black and White racial groups still exists (18). Differences based on race have also been noted individually for each ACSC. For example, Cook et al., 2006 investigated racial disparities in hospitalizations related to diabetes and found that Non-Hispanic Blacks experienced more than triple the hospitalizations compared to Non-Hispanic Whites (118). Similarly, a separate study focusing on hypertension revealed that from 2004 to 2009, Black individuals consistently had higher crude hospitalization rates due to hypertension than White individuals in each year analyzed (24).

2.2.1.2 Socioeconomic status

SES has been defined as a composite measure of an individual's economic and social position based on education, income, and occupation (119). Research in healthcare settings across the US and UK have consistently demonstrated that a higher SES is associated with better health outcomes compared to a lower SES (120,121). Insights from a 1998 United States health statistics report indicated that individuals from lower SES backgrounds exhibit a reduced life expectancy relative to their higher SES counterparts (122). This report also highlighted a gradient in health status, with adults earning lower incomes reporting poorer health conditions more frequently than those with higher incomes. SES was also found to be associated with various chronic conditions such as heart disease, high blood pressure, arthritis, diabetes, and cancer (122). This disparity is

further reflected in hospitalization rates for conditions deemed avoidable, with significantly higher rates observed within the lowest income populations (122).
A study examining how much a person's income, and level of education might be related to preventable hospitalizations reported that individuals with lower income and low educational levels are disproportionately affected by multiple chronic health conditions, heightening their risk of preventable hospitalizations (20). Another study examined preventable hospitalization rates for the residents of New York city by neighborhood poverty from 2008 to 2013. Although a general decline in preventable hospitalizations was noted, the findings indicated significantly higher rates in high poverty neighborhood compared to the low poverty neighbourhood (42). The observed patterns were not only restricted to overall PAH but were also consistently evident across individual ACSCs. Christensen et al., 2011 chose to analyze education as a factor of SES in its correlation with heart failure risk, demonstrating a substantial association (123). Similar associations were also identified in the context of diabetes (124,125).

2.2.1.3.1 Geographic region

Geographic location is associated with wide variations in health care access, health care use, and health status (126). It has been suggested that where a person resides, or features of a particular area, can have a direct impact on his or her health outcomes and mortality (127). Research shows that there are systematic disparities in morbidity, mortality, and other measures of well-being across different areas of the country, even across small areas that lie relatively close together. Historically, health studies have often compared health outcomes and life expectancy across broad geographic areas, revealing that certain health conditions tend to cluster in specific areas (128,129). These patterns highlight regional disparities in health risks and outcomes.

Prior research has explored geographic variation in the context of PAH. Existing studies have reported higher rates of PAH in the South with the lower rates observed in the West (21,22). Additionally, research focusing on geographic variation in individual ACSCs, including conditions like heart failure (130), diabetes (21), hypertension (24), and COPD (131), supports this trend, showing similar regional disparities in hospital admissions.

2.2.1.4 Sex

The World Health Organization's framework on Social Determinants of Health (SDH) identifies sex as a key factor that shapes overall health outcomes and contributes to the disparities seen in health across populations (132). In conjunction with other social determinants, sex influences health outcomes by creating variations in exposure to the intermediate factors that determine health. Evidence suggests that males generally have a shorter lifespan and higher fatality rates from major causes of death than females (133, 134). Health differences between men and women are influenced by structural factors like income and education, behavioral factors such as smoking and physical activity, and psycho-social elements like stress, and alcohol or substance abuse (134,135). Crimmins et al., 2019 also found that despite the heterogeneity in risk factors for chronic conditions, males are more prone to life-threatening diseases like, stroke, heart disease, diabetes while females are more likely to experience chronic conditions that are incapacitating but not life-threatening (133). This pattern extends to avoidable hospitalizations due to ACSCs where males are more likely to experience such admissions (18,136).

2.2.1.5 Age

Aging involves progressive changes in health and functional status, leading to an increased demand for diverse healthcare services and resources to manage evolving health challenges over time (137). Numerous studies have demonstrated a correlation between advancing age and a decline in health outcomes and quality of life (139,140). Contributing factors to this decline encompass a spectrum of issues such as the prevalence of multiple comorbidities, the necessity for long-term management of chronic illnesses, various disabilities, and social isolation issues (138,141-143). Furthermore, this decline is particularly evident in studies of PAH, where there is a marked tendency for older adults to be hospitalized due to ACSCs (44,136,144). Loyd et al., 2023 categorized participants into various age cohorts, beginning from <45 to ≥90 years. This study demonstrated that hospitalization rates for ACSCs were disproportionately higher in the oldest age group, underscoring the healthcare needs within this demographic (18).

Chapter 3

3 Association of Sociodemographic Factors with Potentially Avoidable Hospitalizations Among Hospitalized Adults in the US

3.1 Introduction

Hospital care constitutes an increasingly large segment of healthcare spending in the United States (2,67). A significant portion of this spending can be saved by avoiding certain types of in-hospital stays, particularly those related to Ambulatory Care Sensitive Conditions (ACSCs). ACSCs are the conditions for which timely and effective outpatient primary care can either prevent the illness or manage its severity, thus decreasing the likelihood of needing hospitalization (4,145). Yet, when primary care is not readily available or is hard to access, ACSCs lead to unnecessary hospital stays (60). Consequently, these avoidable hospital admissions increase both hospital occupancy and overall healthcare costs due to worse health outcomes resulting from delayed care (5,6). An assessment of ACSCs using national dataset indicated that in 2006, hospital expenses for nearly 4 million potentially avoidable hospitalizations reached close to $31 billion (73), this figure increased to approximately $34 billion by 2017 (7). Given this substantial impact on health systems and patients, addressing potentially avoidable hospitalizations (PAH) has emerged as a priority among policymakers and public and private payers.

Previous research has identified heterogeneity in patient-level sociodemographic characteristics, as well as geographic variations in availability, accessibility and perceived quality of healthcare, as potential factors influencing hospital admissions for ACSCs. It has been observed that being Black, Hispanic, or other minority racial groups (15,98,146) as well as residing in low and middle-income areas (15,19,146), show a strong association with potentially avoidable hospital admissions. Regional disparities have also been documented in studies, with the Southern regions of the US reporting the highest rates of PAH, in contrast to the Western regions where the lowest rates are observed (21,22).

Most studies exploring the factors influencing ACSCs hospitalizations have been narrow in scope i.e., they have focused on particular ACSC, specific geographic areas or population groups; therefore, they do not fully represent the broader population. For instance, previous research has examined variation in admission rates for specific conditions such as diabetes (23,44,98), hypertension (24,44,98), heart failure (44,98,28,130,29), and COPD (44,98,25,131). Some studies have restricted their investigation to specific age groups, either those below 64 years (44,27) or those above 64 years (15,41,16) or concentrated on any specific region within the US (15,16,27,42,43,147,148). O'Connell et al., 2017 evaluated racial disparities in ACSCs hospitalizations, but only between American Indian, Alaskan Native, and White groups (17). Loyd et al., 2023 studied variations in age, gender, and race for ACSCs hospitalizations using data for a single year but did not investigate the role of socioeconomic status (SES) (18). In contrast, Roos et al., 2005 investigated only SES disparities in PAH (149).

Limited studies have explored the influence of multiple demographic, socioeconomic, and geographic characteristics on PAH. Moreover, there is a gap in our understanding of recent trends in ACSCs hospitalizations using latest multi-year data. Therefore, a thorough investigation of the association of multiple social factors with ACSCs admissions at a national scale. To address this gap, this study aims to investigate the association of sociodemographic factors with potentially avoidable hospitalizations among the hospitalized adult population in the US using recent multi-year data. Insight from this study can inform public health and healthcare policy decisions to improve access to timely care to prevent hospitalization.

3.2 Methods

3.2.1 Study design and sample population

We conducted a retrospective study of adult hospitalized patients in the US using the Health Care Utilization Project (HCUP) National Inpatient Sample (NIS) database. The NIS is the largest publicly available inpatient database in the US, encompassing discharge

summary records of 20% stratified random sample of community hospitals across participating states (150). This approach ensures that the database comprehensively represents health outcomes and experiences of 98% of the US population (150). The study population consisted of a total of 17,629,891 hospital discharges for all cause hospitalizations between 2018 and 2020 among adults aged 18 years or older.

3.2.2 Exposure and outcome measures

The outcome of interest was a binary indicator of whether a hospitalization event was potentially avoidable (PAH). PAH were determined using the Agency for Healthcare Research and Quality's (AHRQ) Prevention Quality Indicators (PQIs) criteria for Ambulatory Care Sensitive Conditions (ACSCs) and coded using International Classification of Diseases, Tenth Revision (ICD-10) (53). Definitions of ACSCs, encompassing various acute and chronic conditions, have been provided in Appendix 1. In this study, acute ACSCs included (1) community acquired pneumonia; and (2) UTI. Chronic ACSCs included (1) hypertension; (2) heart failure; (3) asthma in younger adults; (4) COPD/ asthma in older adults; (5) diabetes with short-term complications; (6) diabetes with long-term complications; (7) uncontrolled diabetes; and (8) lower-extremity amputation among diabetic patients. In this study, the phrases 'ACSCs hospitalizations' and 'PAH' have been used interchangeably.

The primary independent variables of interest in this study included race, socioeconomic status (SES), age, sex and geographic location. The patient's race or ethnicity was categorized based on the classifications outlined in the NIS as follows: White, Black, Hispanic, Asian or Pacific Islander, Native American, and other ethnic groups. In the context of this research, race was utilized as a social construct rather than a biological variable. SES was estimated using median household income for the patient's zip code where the patient resides and categorized into four quartiles ranging from the poorest ($<25^{th}$ percentile) to the richest ($>75^{th}$ percentile). Hospital census regions were based on geographic locations in the following regions: Northeast, Midwest, South and West. The age variable encompassed individuals aged between 18 and 90 years. Sex was identified as either male or female in the NIS dataset.

3.2.3 Statistical Analysis

Demographic and clinical characteristics for patients with ACSCs and non-ACSCs admissions were reported in terms of percentages for categorical variables and mean +/- standard deviation for continuous variables. Given that the proportion of missing data was minimal across all variables(less than 5% of total observations), we opted not to employ imputation techniques. Rates of PAH were calculated by dividing the number of ACSCs-related hospital admissions by the total number of hospital admissions in the same year.

After merging data from three years (2018-2020), we employed a multivariable multilevel logistic regression model to investigate the relationship between PAH and sociodemographic factors. This model controlled for the covariates mentioned below and accounted for clustering of admissions within hospitals. Additionally, fixed effects were incorporated into the model to manage the influence of the calendar years from 2018 to 2020. Both unadjusted and adjusted odds ratios along with 95% confidence intervals and p-values were reported.

To evaluate the potential influence of COVID-19 pandemic on the association of race and SES with PAH, a separate multilevel logistic regression analysis with interaction term was carried out. A new binary variable was constructed, with 2018 and 2019 as pre-pandemic years and 2020 as the pandemic year. The interaction was between race and pandemic-year and SES and pandemic-year. Other covariates were also included in the model. The odds ratios along with 95% confidence intervals and p-values were reported. Sensitivity analyses were performed to assess the potential influence of excluding a variable for expected primary payer and individual comorbid conditions from the fully adjusted models. All analyses were conducted using Stata v14.2 statistical software (194).

To separate the effect of the primary exposures on the outcome, our model controlled for potential known confounding variables in the analysis. All covariates used in the model were defined a priori, guided by existing literature and clinical knowledge. These covariates included expected primary payer (Medicare, Medicaid, private insurance, self-pay, no charge, other), hospital location/ teaching status (rural, urban nonteaching, urban teaching), and hospital bed size (small, medium, large), lifestyle-related factors (smoking history, alcohol abuse, drug abuse, and obesity), selected clinical comorbidities, and

comorbidity scores. Among these, factors like lifestyle choices, and comorbidities are frequently recognized as potential confounders (20,151-154). Elixhauser Comorbidity Software was utilized to identify the comorbid conditions and to calculate comorbidity scores (155). The selected covariates also align with Andersen's Behavioral Model, including predisposing factors (age, sex, race/ethnicity), enabling factors (income), and need variables (comorbidities, and comorbidity scores) (111).

3.3 Results

3.3.1 Patient characteristics

Between 2018 and 2020, we identified a total of 17,629,891 hospitalizations among individuals aged 18 years and older in the United States. Of these, 1,868,609 (10.6%) were due to ACSCs, while the remaining 15,761,282 (89.4%) resulted from non-ACSCs causes.

The mean age for the patients admitted due to ACSCs was 66.2 ± 16.9 (Table 3.1). Regarding sex distribution, 52.2% of PAH admissions were female. Approximately 65% of admissions were identified as White, followed by 20.4% Black, 9.8% Hispanic, 1.9% Asian or Pacific Islander, 0.6% Native American, and 2.4% other or unspecified. Among the individuals from different income quartiles, 35.4% of admissions were from the lowest income quartile, whereas 15.6% were from the highest quartile. Geographically, most of the admissions occurred in the South (43.5%), with the Midwest, Northeast, and West regions accounting for 21.8%, 18.3%, and 16.4% of admissions, respectively (Table 3.1). Comprehensive sample characteristics for each year are provided in Appendix 8.

Table 3.1: Characteristics of the study population by type of hospitalizations

N=17,629,891	ACSCs Hospitalizations n=1,868,609	Non-ACSCs Hospitalizations n=15,761,282
Patient-level characteristics, n (%)		
Age (mean ± SD)	66.2 ± 16.9	57.2 ± 20.3
Sex		
Male	893,372 (47.8%)	6,708,360 (42.6%)
Female	975,169 (52.2%)	9,051,128 (57.4%)
Race		
White	1,191,332 (65.0%)	10,270,037 (66.8%)
Black	373,174 (20.4%)	2,275,837 (14.8%)
Hispanic	179,253 (9.8%)	1,793,529 (11.7%)
Asian or Pacific Islander	35,184 (1.9%)	447,368 (2.9%)
Native American	11,148 (0.6%)	106,538 (0.7%)
Other	43,387 (2.4%)	472,087 (3.1%)
Median household income quartile		
Poorest	650,164 (35.4%)	4,596,004 (29.7%)
Second poorest	499,514 (27.2%)	4,099,079 (26.5%)
Second richest	398,665 (21.7%)	3,694,733 (23.9%)
Richest	286,628 (15.6%)	3,087,986 (20.0%)
Hospital region		
Northeast	341,626 (18.3%)	2,903,110 (18.4%)
Midwest	407,445 (21.8%)	3,501,108 (22.2%)
South	813,032 (43.5%)	6,221,311 (39.5%)
West	306,506 (16.4%)	3,135,753 (19.9%)
Lifestyle factors, n (%)		
Smoking history	864,456 (46.3%)	5,521,199 (35.0%)
Obesity	422,657 (22.6%)	2,757,231 (17.5%)
Drug abuse	92,381 (4.9%)	883,162 (5.6%)
Alcohol abuse	71,575 (3.8%)	908,947 (5.8%)
Comorbidities, n (%)		
Hypertension, complicated	451,194 (24.2%)	3,430,837 (21.8%)
Hypertension, uncomplicated	499,245 (26.7%)	5,063,070 (32.1%)
Diabetes with chronic complications	677,185 (36.2%)	2,404,741 (15.3%)
Diabetes without chronic complications	182,905 (9.8%)	1,631,902 (10.4%)
Metastatic cancer	27,943 (1.5%)	526,115 (3.3%)
Cerebrovascular disease	82,608 (4.4%)	724,420 (4.6%)
Liver disease, mild	96,431 (5.2%)	816,984 (5.2%)
Liver disease, severe	14,730 (0.8%)	284,885 (1.8%)
Renal failure, moderate	392,553 (21.0%)	1,533,529 (9.7%)
Renal failure, severe	217,291 (11.6%)	870,077 (5.5%)
Elixhauser comorbidity score (median (IQR))		
Mortality score	7 (17)	0 (15)
Readmission score	11 (13)	5 (12)

This study also provides an overview of the contribution of ACSCs in PAH (Table 3.2). Although the distribution of ACSCs is not the central focus of this study, its presentation provides essential contextual foundation that enhances understanding of our main objective. Most of the ACSCs hospital admissions were attributed to heart failure, accounting for 34.1% of all ACSCs hospitalizations. Admissions due to COPD and community acquired pneumonia accounted for 16.3% and 13.5% of all ACSCs hospitalizations, respectively. The least common ACSC for PAH was adult asthma, at just 0.8%. Based on observation, rates of PAH due to hypertension, heart failure, and diabetes related complications had increasing trend whereas, the rates of COPD, adult asthma, pneumonia, and UTI admissions showed a decreasing trend over the years of 2018 to 2020.

Table 3.2: Distribution of Ambulatory Care Sensitive Conditions in the sample

ACSCs	Distribution in the study population, n (%)			
	Overall	2018	2019	2020
Hypertension	90,487 (4.8%)	31,005 (4.7%)	32,220 (4.8%)	27,262 (5.1%)
Herat Failure	638,024 (34.1%)	218,556 (32.9%)	226,272 (34.0%)	193,196 (35.8%)
COPD or Asthma in Older Adults	304,045 (16.3%)	119,495 (18.0%)	113,374 (17.0%)	71,176 (13.2%)
Asthma in Younger Adults	15,162 (0.8%)	5,799 (0.9%)	5,660 (0.9%)	3,703 (0.7%)
Community Acquired Pneumonia	253,034 (13.5%)	93,578 (14.1%)	90,778 (13.6%)	68,678 (12.7%)
Diabetes Short-Term Complications	127,517 (6.8%)	42,343 (6.4%)	42,595 (6.4%)	42,579 (7.9%)
Diabetes Long-Term Complications	168,889 (9.0%)	55,443 (8.4%)	59,431 (8.9%)	54,015 (10.0%)
Uncontrolled Diabetes	61,833 (3.3%)	21,634 (3.3%)	21,444 (3.2%)	18,755 (3.5%)
Lower-Extremity Amputation Among Patients with Diabetes	51,522 (2.8%)	16,448 (2.5%)	17,313 (2.6%)	17,761 (3.3%)
Urinary Tract Infection	187,365 (10.0%)	68,721 (10.4%)	66,616 (10.0%)	52,028 (9.7%)

3.3.2 Association between sociodemographic factors and PAH

Results of the unadjusted and adjusted multivariable multilevel logistic regression analyses examining the factors associated with PAH are presented in Table 3.3. The results indicated that the adjusted odds of a hospital event being ACSCs were higher for the hospitalized individuals who self-identified as Black [OR 1.65, 95% CI 1.64-1.66], Hispanic [OR 1.19, 95% CI 1.18-1.19], and those from other or unspecified [OR 1.02, 95% CI 1.01-1.03] race groups compared to those of the White race group. While patients from Asian or Pacific Islander [OR 0.98, 95% CI 0.97-0.99] race group had lower odds of PAH compared with White patients, patients from Native American [OR 1.01, 95% CI 0.99-1.03] race group did not have statistically significant association after accounting for potential confounding factors.

The adjusted odds of ACSC admissions resulting from the avoidable causes were highest among hospitalized patients in the lowest (poorest) SES quartile [OR 1.21, 95% CI 1.20-1.22] followed by the second lowest [OR 1.13, 95% CI 1.12-1.13], and third lowest SES quartiles [OR 1.08, 95% CI 1.08-1.09] as compared to those in the highest SES quartile. In terms of hospital census region, the higher odds of avoidable hospital admissions were observed in the South [OR 1.04, 95% CI 1.01-1.07] and lower odds were in the West [OR 0.87, 95% CI 0.84-0.91], and Midwest [OR 0.88, 95% CI 0.85-0.91] regions when compared to the Northeast region. The study also showed that increasing age [OR 1.02, 95% CI 1.02-1.02], and male sex [OR 1.03, 95% CI 1.03-1.04] were associated with higher likelihood of experiencing PAH. Additionally, compared to 2018, lower odds of PAH were observed in 2019 [OR 0.99, 95% CI 0.98-0.99], and 2020 [OR 0.84, 95% CI 0.83-0.84] (Appendix 12).

Table 3.3: Unadjusted and fully adjusted association of exposures of interest (race, median household income quartiles for patient's ZIP code, hospital region, age, sex) with PAH

N=17,629,891	Unadjusted Odds ratios [95% confidence intervals] and *P* values	Adjusted Odds ratios [95% confidence intervals] and *P* values
Age	1.03 [1.03-1.03] *P*<0.001	1.02 [1.02-1.02] *P*<0.001
Sex		
Female	*Reference Category*	
Male	1.14 [1.14-1.15] *P*<0.001	1.03 [1.03-1.04] *P*<0.001
Race		
White	*Reference Category*	
Black	1.66 [1.66-1.67] *P*<0.001	1.65 [1.64-1.66] *P*<0.001
Hispanic	1.11 [1.10-1.12] *P*<0.001	1.19 [1.18-1.19] *P*<0.001
Asian or Pacific Islander	0.88 [0.87-0.89] *P*<0.001	0.98 [0.97-0.99] *P*<0.05
Native American	1.15 [1.12-1.17] *P*<0.001	1.01 [0.99-1.03] *P*=0.41
Other	0.95 [0.94-0.96] *P*<0.001	1.02 [1.01-1.03] *P*<0.05
Median household income quartile for patient's ZIP Code		
Richest	*Reference Category*	
Second richest	1.16 [1.16-1.17] *P*<0.001	1.08 [1.08-1.09] *P*<0.001
Second poorest	1.29 [1.28-1.29] *P*<0.001	1.13 [1.12-1.13] *P*<0.001
Poorest	1.43 [1.43-1.44] *P*<0.001	1.21 [1.20-1.22] *P*<0.001
Region of hospital		
Northeast	*Reference Category*	
Midwest	1.04 [1.01-1.08] *P*<0.05	0.88 [0.85-0.91] *P*<0.001
South	1.09 [1.05-1.13] *P*<0.001	1.04 [1.01-1.07] *P*<0.05
West	0.89 [0.86-0.93] *P*<0.001	0.87 [0.84-0.91] *P*<0.001

3.3.3 Interaction between race and year, and SES and year

Additional analyses were performed to examine the interaction between race and year, and SES and year (Table 3.4). The findings suggested that compared to the years 2018 and 2019, hospitalized patients who self-reported as Hispanic [OR 0.96, 95% CI 0.95-0.97], Asian or Pacific Islander [OR 0.95, 95% CI 0.93-0.98], and patients from unspecified [OR 0.97, 95% CI 0.95-0.99] race groups had lower odds of PAH due to ACSCs in 2020. However, there was not a statistically significant difference in the odds of PAH admissions in 2020 for Black [OR 1.01, 95% CI 1.00-1.02] and Native American [OR 0.97, 95% CI 0.93-1.02] patients compared to White patients who experienced PAH in 2018 and 2019. When compared to the patients from richest quartile hospitalized in 2018 and 2019, those who were in the poorest quartile [OR 1.01, 95% CI 1.01-1.03] were more likely to experience PAH in 2020. Patients belonging to second poorest [OR 1.01, 95% CI 1.00-1.02], and second richest [OR 1.00, 95% CI 0.99-1.02] quartiles experiencing PAH in 2020 did not have any statistically significant difference with those of richest quartile admitted in 2018 and 2019.

Table 3.4: Odds ratios [95% Confidence Intervals] and *P* values for interaction analysis between race and year and median household income quartiles and year

Variables	Year	
	2020	2018 & 2019
Race		
White	*Reference Category*	
Black	1.01 [1.00-1.02] *P*=0.16	*Reference*
Hispanic	0.96[0.95-0.97] *P*<0.001	*Category*
Asian or Pacific Islander	0.95 [0.93-0.98] *P*<0.001	
Native American	0.97 [0.93-1.02] *P*=0.20	
Other	0.97 [0.95-0.99] *P*<0.05	
Median household income quartile for patient's ZIP Code		
Richest	*Reference Category*	
Second richest	1.00 [0.99-1.02] *P*=0.47	*Reference*
Second poorest	1.01 [1.00-1.02] *P*=0.10	*Category*
Poorest	1.01 [1.01-1.03] *P*<0.05	

3.3.4 Sensitivity analysis

Sensitivity analyses were performed by excluding expected primary payer and individual comorbid conditions from the regression models (Appendix 21). The results reported that compared to patients of White race group, the odds of PAH were higher among hospitalized Black individuals [OR 1.57, 95% CI 1.57-1.58]. However, a slight decrease in the odds for this race group was observed relative to the fully adjusted model (Table 3.3). Patients of Hispanic [OR 1.20, 95% CI 1.19-1.21] and other or unspecified [OR 1.03, 95% CI 1.02-1.05] racial groups had higher odds of PAH compared to White patients. However, while the association between Native American race group and PAH was not statistically significant in the fully adjusted model, patients of this group [OR 1.03, 95% CI 1.01-1.05] had higher odds compared to White patients after removing these covariates from the model. Conversely, fully adjusted model reported lower odds of PAH for Asian or Pacific Islander race group compared to White patients, which did not remain statistically significant [OR 0.99, 95% CI 0.99-1.00] after excluding these covariates.

SES categories were comparable before and after exclusion of these variables with showing higher odds of PAH among hospitalized individuals of lowest [OR 1.23, 95% CI 1.23-1.24], second lowest [OR 1.15, 95% CI 1.15-1.16], and third lowest [OR 1.10, 95% CI 1.09-1.10] income groups compared to those of highest income groups. In terms of geographic location, the Midwest [OR 0.89, 95% CI 0.86-0.92] and West [OR 0.87, 95% CI 0.84-0.90] regions had lower odds of PAH compared to the Northeast region. However, the odds of PAH for the admissions in the Southern region [OR 1.02, 95% CI 0.99-1.05] were no longer statistically significant after the exclusion. Results also reported that advancing age [OR 1.02, 95% CI 1.02-1.02], and male sex [OR 1.09, 95% CI 1.08-1.09] of the patients had higher likelihood of experiencing PAH.

3.4 Discussion

Using the nationally representative NIS data from 2018 to 2020, this study found a strong association between sociodemographic factors and PAH among hospitalized adult patients in the US, after accounting for potential confounders. Specifically, we observed that older age, male sex, Black or Hispanic race and low income were associated with higher odds of experiencing PAH when compared with female sex, White race, and high income, respectively. In terms of geographical factors, hospital admissions in the South census region were linked to higher odds of PAH compared to the Northeast region.

3.4.1 Association between race and PAH

The association of PAH with race has been documented in the previous literature, particularly in relation to the individuals who are Black, Indigenous, and People of Color (BIPOC). These studies have observed more frequent avoidable hospital admissions due to ACSCs among BIPOC individuals (15,16,43,98,148,156,157). Our study did not find a statistically significant association between Native American ethnicity and PAH. However, some studies have found higher odds of avoidable hospitalizations in this group (17,18). This could partly be explained by heterogeneity between studies. For instance, Loyd et al., 2023 employed alternative criteria known as Purdy definitions, for identifying ACSCs (18). Purdy definitions comprise 36 conditions and differ in their selection of ICD-10 codes compared to those established by AHRQ for identifying these conditions (18). Another study limited their analysis to Medicare beneficiaries rather than the full sample of NIS patients (17). There are documented concerns around the accuracy of coding of Native American ethnicity in Medicare data (158,159) that may explain differences in reported associations.

Several factors may contribute to the observed differences in PAH among different racial groups. Limited access to quality outpatient care has been reported as an important determinant of higher rates of avoidable hospitalization in minority racial groups (24,157,160,161,162). The disparities in the use of ambulatory care among Black and Hispanic individuals may be influenced by cultural and language barriers, as suggested by previous studies (62-64). Evidence also shows that limited health insurance coverage

may explain access challenges in some individuals of minority racial groups (163). While our analysis controlled for insurance status, we found that the influence of race on PAH remained significant. Studies have explored alternative factors contributing to this complex relationship. For instance, Hicks et al., 2005 found that racial minorities, particularly African American and Hispanic patients reported that their treatment preferences were often not taken into account in care planning which may result in lower adherence to treatment and higher likelihood of avoidable hospitalization (165). Collectively, these elements may partly explain the higher odds of PAH among people from BIPOC community.

3.4.2 Association between SES and PAH

In this study, we found that patients in low and middle SES quartiles were more likely to experience PAH when compared with patients from high SES quartile. This finding is consistent with previous studies highlighting variations in avoidable hospitalization among people across different socioeconomic groups (15,19,20,42,44,149,156). A monotonic relationship was observed in our study between income level and PAH; this is consistent with the findings of Agabiti et al., 2009 who documented an inverse relationship between income level and ACSCs hospitalization rates in population of Italy (44). This association is also observed at neighborhood level studies that report economically disadvantaged areas to have more frequent hospital admissions due to ACSCs in comparison to affluent areas (25,149). The observed disparity might be explained by perceived superior quality and easy accessibility of hospital care (167). Furthermore, higher prevalence of chronic illnesses and inadequate care to manage these conditions may explain the association of PAH with lower socioeconomic status (20,154). A qualitative study exploring the experiences of patients from economically disadvantaged communities admitted due to ACSCs shed further light on this issue. It highlighted their significant social vulnerability, communication issues with healthcare providers, limited health-related knowledge, behavioral challenges, and a tendency to underestimate their illness as contributing factors (57).

3.4.3 Association between geographic location and PAH

In comparison to the Northeast census region, our fully adjusted analyses found that the South region was associated with higher odds, while the West and Midwest exhibited lower odds of PAH due to ACSCs. These findings resonate with prior studies investigating regional disparities in PAH (21,22,25,26,29,130,131,172). These regional disparities could be influenced by a range of underlying factors. Historically, lower access to quality primary care in different geographic areas has been identified as a key driver of difference in ACSCs rates (3,29,173). Factors like area-level disease burden, general health status of the population, unnecessary reliance on hospital services available in an area, distance to health services and the number of available general physicians were identified as crucial in determining healthcare utilization patterns to explain regional variation in ACSCs (174). In addition, other potential contributing factors identified are ease of accessing secondary care, higher availability of hospital beds, and hospital staffing levels (175). Another critical aspect influencing such disparities is the travel time required for patients to reach healthcare facilities. In a study on US veterans' health-care system data, Finegan et al., 2010 found that patient travel time of less than 30 minutes to the nearest providers was associated with fewer ACSCs hospitalizations (173).

3.4.4 Association between age and PAH

In this study, the findings showed that the odds of PAH increased with age, after adjusting for potential confounders. This concurs with existing literature that has consistently demonstrated a higher proportion of PAH among older populations (18,44,136,144). Among older adults, various factors such as comorbidities, functional status at the time of admission, and cognitive impairment are significant factors that can complicate the management of ACSCs, leading to a higher likelihood of hospitalization (176). Evidence suggests that elderly individuals without social support are more likely to delay seeking necessary medical care compared to those with social support (178). Such delays, especially among elderly populations, can exacerbate existing chronic conditions, potentially leading to a point where hospitalization becomes unavoidable (131).

3.4.5 Association between sex and PAH

In alignment with previous research, our analyses found that males are more likely to experience PAH compared to females (18,136,179). There are some studies, such as Shi et al., 1999 that has reported an increased rate of PAH among females (144). However, this study utilized data from a specific geographical area and did not include individuals aged above 65 years, which may account for the discrepancy.

One potential explanation of sex-related differences in PAH is that men tend to engage in riskier health behaviors than women. These behaviors include smoking, unhealthy eating patterns, excessive alcohol consumption, and greater prevalence of injury and interpersonal violence (180,181). Further Zwolinsky et al., 2016 demonstrated that men generally rate their health more favorably than women, despite utilizing healthcare services less frequently. This overestimation of personal health, combined with a propensity for unhealthy lifestyle choices, has been linked to an increased risk of chronic conditions such as cardiovascular diseases, diabetes, and respiratory illnesses (182).

3.4.6 Impact of COVID pandemic on the association between race and SES, and PAH

In this additional analysis, we briefly examined the overall pattern in PAH as well as the association of race and SES on PAH during the pandemic of 2020 compared to the pre-pandemic years of 2018 and 2019. In line with previous research (183, 184), our results indicated a general decline in PAH and in racial differences in PAH during pandemic. Leuchter et al., 2021 compared the magnitude of change in PAH during the pandemic in African American and non-Hispanic White groups and reported a significantly larger decline in ACSCs hospitalizations for non-Hispanic Whites than the African Americans (184). However, in our interaction analysis, although there was an overall decrease in the odds of PAH during the pandemic in comparison to pre-pandemic years, this decrease was not statistically significant for Black patients when compared to White patients. The present study also found that relative to pre-pandemic years, patients of Hispanic, Asian or Pacific Islander, and patients from other/ unspecified race groups had lower odds of PAH than White patients during the pandemic. This disparity may be attributed to the differential uptake of telehealth services during the pandemic, as evidenced by studies showing increased telehealth utilization among Hispanic and other racial groups,

excluding Black people, for ACSCs management compared to White people (185). Further supporting this, another study highlighted a lower propensity among Black individuals to use telemedicine services relative to White individuals (186).

Patients in the lowest SES quartile exhibited higher odds of PAH during the pandemic compared to those in the highest SES quartiles in the pre-pandemic time, aligning with previous research (48,187). It is crucial to underline the scarcity of research exploring how the pandemic influenced the direct relationship between SES and PAH. Insights from UK healthcare studies provide a context for our findings, suggesting that individuals experiencing disruptions in accessing medications, medical procedures, surgeries, or physician appointments during the pandemic faced an increased risk of hospital admissions due to ACSCs (188,189). Additionally, these healthcare disruptions were more prevalent among individuals with lower-wage employment during the pandemic (189).

3.4.7 Implications

This research highlights the increased odds of hospitalizations due to ACSCs among individuals from BIPOC community and of low SES groups. It underscores the necessity of implementing targeted strategies to enhance primary care access and quality in these groups (219). System-level interventions are recommended to address this issue effectively. These should include comprehensive patient education, improved communication within healthcare settings, and the provision of continuous care aimed at reducing avoidable hospitalizations (51). Additionally, the regional disparities observed in this context necessitate the development of health improvement strategies at the area level, ensuring an adequate supply of health professionals and continuity of care. Furthermore, effective measures should be taken to raise patient awareness of their condition, secure sufficient insurance coverage, and strengthen the capabilities of healthcare providers in economically disadvantaged communities (220).

3.4.8 Strengths and limitations

This study has a number of strengths. Firstly, the study used nationally representative data on hospitalized patients. Secondly, this study used the most current list and

definitions of ACSCs released in 2022 by AHRQ to comprehensively identify all conditions. Furthermore, the study used data from multiple years of NIS, including the most recent fiscal year available at the time of analysis, making the findings relevant to the current policy context.

However, this study has several limitations. The NIS dataset records multiple admissions for a single individual within the same year as distinct occurrences; however, due to the data being deidentified, it is not possible to account for the correlation among multiple admissions in the analysis. Secondly, in our study, SES was solely defined by the median income of the patient's ZIP code. Nevertheless, this is common in research based on health administrative data that does not include individual-level income information (15,44). Another limitation relates to data on race which is based on self-identification. While this approach is considered most reliable, mis-categorization of racial information is not uncommon in administrative data (158,170). Moreover, the NIS data includes large racial categories, such as Black and White race. While this is commonly used in literature, it ignores significant heterogeneity within each racial group. This analysis used data on patients who were admitted in hospital; however, the decision to seek hospital care and be admitted may not be randomly distributed in the population.

In our regression model, we incorporated several comorbidities along with comorbidity scores; notably, some of these comorbidities are also included in our outcome variable as ACSCs. However, it should be noted that the dependent variable in our study is not the presence of ACSCs but rather the incidence of hospitalizations attributed to any of the ACSCs. Moreover, while adjusting for Elixhauser comorbidity score enables us to control for the overall severity of an individual’s health condition, it does not allow adjustment for specific conditions diagnosed as secondary (i.e. different to the primary cause of ACSC admission). In terms of our analysis of the interaction with the pandemic period, the time frame used in our analysis has limitations. Although the pandemic was officially declared in March 2020, the pandemic year in our analysis includes patients hospitalized in January and February 2020 because of the annual nature of NIS data. As a result, the observed change in the association between sociodemographic factors and PAH may not

be generalizable to the pandemic period. Finally, despite controlling for possible confounders, it's crucial to note that residual confounding may still affect this study.

3.5 Conclusion

This study identifies race, socioeconomic status, geographic location, age, and sex as relevant determinants of potentially avoidable hospital admissions. It emphasizes the significant association of older age, male sex, Black or Hispanic race, low income, and residence in the Southern region with PAH. These findings underscore the need for targeted policy interventions and healthcare strategies that specifically address the disparities in these communities. To inform such interventions, we recommend in-depth qualitative research in these underserved areas, focusing on barriers to healthcare access, patient-provider communication patterns, and the impact of local health policies on patient outcomes. Future research should aim to provide actionable insight for healthcare providers and policymakers, guiding the development of tailored healthcare services and policy reforms.

Chapter 4

4 Association of Race, SES, and Geographic Region with Each Type of Ambulatory Care Sensitive Condition Among Hospitalized Adults in the US

4.1 Introduction

Ambulatory Care Sensitive Conditions (ACSCs) represent a range of health issues for which effective outpatient primary care can potentially prevent the need for hospitalization. The Agency for Healthcare Research and Quality (AHRQ) has identified several ACSCs (53), highlighting their role as indicators of the quality and accessibility of primary healthcare (99). Evidence suggests a correlation between the utilization of primary care and mortality for several ACSCs (191), with some of the ACSCs being major contributors to adult mortality in the US (192). Despite advancements in healthcare systems, avoidable hospitalizations for ACSCs persist as a significant concern, underscoring the deep-seated disparities that continue to exist within these systems. These unnecessary hospitalizations impose financial burdens and consume valuable healthcare resources. Reducing these admissions could substantially conserve resources, particularly in terms of hospital bed occupancy, thereby relieving pressure on healthcare facilities (6).

Previous studies have identified heterogeneity in sociodemographic characteristics in the context of preventable hospitalizations, showing an increased incidence of admissions due to ACSCs among Black, Hispanic, and other minority racial groups (15,146) as well as among people with low SES (15,19). Studies also found differences across regions, specifically highlighting higher rates of ACSCs admissions in the Southern regions of the US (21,22). However, research is limited in investigating the distinct associations between each ACSC and multiple sociodemographic factors. Prior studies have either examined a single ACSC (23-25,28,29,130,131) or restricted their investigation to single sociodemographic factor (25,28,29). For instance, Agabiti et al., 2009 and Ladtika & Ladtika, 2006 examined all chronic conditions individually, however, their research was restricted to SES groups only (44,98). This leaves a gap in understanding the influence of

multiple sociodemographic factors on avoidable hospitalizations for each specific ACSC. Additionally, there's a lack of current data on recent trends in ACSCs hospitalizations. The present study aims to bridge these gaps by examining the association of racial, and socioeconomic, and geographic factors with each type of ACSCs among hospitalized patients in the US, utilizing recent multi-year data.

4.2 Methods

4.2.1 Study design and sample population

We conducted a retrospective study of adult hospitalized patients in the US using the Health Care Utilization Project (HCUP) National Inpatient Sample (NIS) database. The NIS is the largest publicly available inpatient database in the US, encompassing discharge summary records of a 20% stratified random sample of community hospitals across participating states. This approach ensures that the database comprehensively represents health outcomes and experiences of 98% of the US population (150). The study population consisted of a total of 17,629,891 hospital discharges for all cause hospitalizations between 2018 and 2020 among adults aged 18 years or older.

4.2.2 Exposure and outcome measures

The outcome of interest was binary indicator of whether a hospitalization event was due to ACSCs. Binary indicators were constructed for each of the ACSCs separately. These conditions were identified using the Agency for Healthcare Research and Quality's (AHRQ) Prevention Quality Indicators (PQIs) criteria and coded using International Classification of Diseases, Tenth Revision (ICD-10) (53). Definitions of ACSCs as well as ICD-10 codes used to identify ACSCs have been provided in Appendix 1 and 2. In this study, acute ACSCs included (1) community acquired pneumonia; and (2) UTI. Chronic ACSCs included (1) hypertension; (2) heart failure; (3) asthma in younger adults; (4) COPD/ asthma in older adults; (5) diabetes with short-term complications; (6) diabetes with long-term complications; (7) uncontrolled diabetes; and (8) lower-extremity

amputation among diabetic patients. To simplify the analysis of relationships, ACSCs variables for diabetes related conditions were combined into a single variable.

The primary exposure variables of interest in this study included race, socioeconomic status (SES), and geographic locations. The patient's race or ethnicity was categorized based on the classifications outlined in the NIS as follows: White, Black, Hispanic, Asian or Pacific Islander, Native American, and other ethnic groups. In this study, race has been considered as a social construct rather than a biological variable. SES was estimated using median household income for the patient's zip code where the patient resides and categorized into four quartiles ranging from the poorest ($<25^{th}$ percentile) to the richest ($>75^{th}$ percentile). Hospital census regions were based on geographic locations in the following regions: Northeast, Midwest, South and West.

4.2.3 Statistical analysis

Demographic characteristics and lifestyle factors of study population for hospitalizations with each ACSC were reported in terms of percentages for categorical variables and mean ± standard deviation or, median and IQR for continuous variables. Given that the proportion of missing data was minimal across all variables (less than 5% of total observations), we opted not to employ imputation techniques.

After merging data from three years (2018-2020), we employed a series of multilevel logistic regression models to investigate the relationship between each ACSC and sociodemographic factors. To maintain the integrity of the effect of exposure variables, the analyses were conducted on data subsets. These subsets encompassed hospitalizations specific to the ACSCs in focus and included all non-ACSCs hospitalizations, facilitating a precise examination of their relationship with the primary exposure variables. These models accounted for the covariates mentioned below and clustering of admissions within hospitals. Additionally, fixed effects were incorporated into the model to manage the influence of the calendar years from 2018 to 2020. The unadjusted and fully adjusted odds ratios for each condition along with 95% confidence intervals and p-values were reported. While the multilevel logistic regression analyses were performed to examine the associations for each condition separately, a multinomial regression analysis was conducted to assess if the associations between each ACSC and sociodemographic factors

significantly differ from one another (Appendix 20). In this analysis, hospital admissions across the sociodemographic groups for each of the ACSCs were compared against admissions with non-ACSCs reasons. However, accounting for clustering of admissions within hospital levels was constrained by the scope of the analytical tool employed in this study. All analyses were conducted using Stata v14.2 statistical software (194).

To separate the effect of the primary exposures on the outcome, our model controlled for potential known confounding variables in the analysis. All covariates were selected a priori, based on existing literature and clinical expertise, to accurately model the relationship between our primary exposures and the outcomes of interest. These covariates included age, sex (male/female), hospital location/teaching status (rural, urban nonteaching, urban teaching), lifestyle-related factors (smoking history, alcohol abuse, drug abuse, and obesity), and comorbidity scores. Of these, elements such as lifestyle factors, and comorbidity scores are often identified as potential confounders (20,151-154). Elixhauser Comorbidity Software was utilized to calculate comorbidity scores (155). The covariates chosen for our model are in line with Andersen's Behavioral Model, which includes predisposing factors (age, sex, race/ethnicity), enabling factors (income), and need variables (comorbidity scores) (111).

4.3 Results

4.3.1 Patient characteristics

A total of 17,629,891 hospitalizations were identified from January 2018 to December 2020 among individuals aged 18 years and older in the US. Of these, 1,868,609 hospitalizations were due to different types of ACSCs. Among these ACSCs hospitalizations, most of the admissions, 34.1%, were due to heart failure, while 0.8% were for asthma in younger adults/ adult asthma (Table 4.1).

The mean age for the patients hospitalized with heart failure was 71.1 ± 14.3. Most of the patients admitted with this condition were male, accounting for 52.4%. Approximately 64% of heart failure admissions were identified as White, followed by Black (22.4%), Hispanic (8.8%), Asian or Pacific Islanders (2.2%), Native American (0.5%), and other/

unspecified race groups (2.3%). Among the individuals from different income quartiles, approximately 34% of admissions were from the lowest and around 17% were from the highest SES quartile. Geographically, most of the admissions occurred in the South (41.9%), with the Midwest, Northeast, and West regions accounting for 22.2%, 18.3%, and 17.6% of admissions, respectively.

For the admissions of adult asthma, the mean age of patients was 29.7± 6.2. Female patients made up the majority, comprising 66.1% of the admissions. In terms of race, admissions due to adult asthma were identified as White, Black, Asian or Pacific Islanders, Native American, and other/ unspecified race groups representing 40.5%, 37.4%, 16.7%, 1.4%, 0.6%, 3.4% of admissions, respectively. 40.7% of hospitalizations occurred in the people of the lowest income quartile, and 13% in the people of the highest income quartile. Admissions in the South census region represented 37.1% of the total adult asthma admissions, while the Northeast, Midwest, and West regions represented 23.4%, 20.6%, and 18.9%, respectively. Table 4.1 presents a detailed summary of these baseline characteristics of the study sample.

Table 4.1: Characteristics of the study population by type of ACSCs

n=1,868,609	Diabetes Related Complications N = 380,760	COPD/Asthma in Older Adults N = 304,045	Hypertension N = 90,487	Heart Failure N = 638,024	Community Acquired Pneumonia N = 253,034	UTI N = 187,365	Asthma in Younger Adults N = 15,162
Age, mean ± SD (years)	55.0 ± 17.6	67.2 ± 11.7	61.7 ± 16.7	71.1 ± 14.3	69.1 ± 16.2	71.4 ± 17.7	29.7 ± 6.2
Sex, n (%)							
Male	222,858 (58.5%)	122,842 (40.4%)	40,313 (44.6%)	334,558 (52.4%)	117,084 (46.3%)	50,760 (27.1%)	5,142 (33.9%)
Female	157,882 (41.5%)	181,194 (59.6%)	50,172 (55.5%)	303,446 (47.6%)	135,939 (53.7%)	136,599 (72.9%)	10,020 (66.1%)
Race, n (%)							
White	205,787 (55.1%)	215,789 (72.3%)	39,933 (45.0%)	400,441 (63.9%)	189,129 (76.5%)	134,350 (73.2%)	6,042 (40.5%)
Black	93,969 (25.1%)	50,603 (16.9%)	32,978 (37.2%)	140,152 (22.4%)	27,920 (11.3%)	22,049 (12.0%)	5,573 (37.4%)
Hispanic	54,251 (14.5%)	20,245 (6.8%)	10,448 (11.8%)	54,936 (8.8%)	18,811 (7.6%)	18,110 (9.9%)	2,490 (16.7%)
Asian or Pacific Islander	6,289 (1.7%)	4,463 (1.5%)	2,349 (2.7%)	14,005 (2.2%)	4,531 (1.8%)	3,344 (1.8%)	209 (1.4%)
Native American	3,535 (1.0%)	1,582 (0.5%)	410 (0.5%)	3,015 (0.5%)	1,511 (0.6%)	1,005 (0.6%)	93 (0.6%)
Unspecified	9,947 (2.7%)	5,952 (2.0%)	2,638 (3.0%)	14,285 (2.3%)	5,436 (2.2%)	4,631 (2.5%)	506 (3.4%)
Median household income quartile for patient's ZIP Code, n (%)							
Poorest	142,079 (38.1%)	112,653 (37.7%)	35,122 (39.5%)	212,591 (33.9%)	83,438 (33.6%)	58,303 (31.6%)	6,078 (40.7%)
Second poorest	101,906 (27.3%)	82,927 (27.8%)	22,950 (25.8%)	167,596 (26.8%)	70,896 (28.5%)	49,426 (26.8%)	3,898 (26.1%)
Second richest	78,702 (21.1%)	61,936 (20.8%)	18,444 (20.7%)	140,308 (22.4%)	54,563 (21.9%)	41,750 (22.6%)	3,010 (20.2%)
Richest	50,417 (13.5%)	40,944 (13.7%)	12,419 (14.0%)	105,911 (16.9%)	39,814 (16.0%)	35,218 (19.1%)	1,938 (13.0%)
Hospital regions, n (%)							
Northeast	65,600 (17.2%)	61,733 (20.3%)	15,844 (17.5%)	117,010 (18.3%)	43,510 (17.2%)	34,424 (18.4%)	3,544 (23.4%)
Midwest	76,574 (20.1%)	70,031 (23.0%)	17,768 (19.6%)	141,603 (22.2%)	58,881 (23.3%)	39,523 (21.1%)	3,126 (20.6%)
South	169,223 (44.4%)	131,356 (43.2%)	43,401 (48.0%)	267,206 (41.9%)	111,453 (44.1%)	84,905 (45.3%)	5,622 (37.1%)
West	69,363 (18.2%)	40,925 (13.5%)	13,474 (14.9%)	112,205 (17.6%)	39,190 (15.5%)	28,513 (15.2%)	2,870 (18.9%)

Lifestyle factors, n (%)							
Smoking history	151,996 (39.9%)	216,155 (71.1%)	35,231 (38.9%)	278,834 (43.7%)	120,561 (47.7%)	54,914 (29.3%)	6,850 (45.2%)
Obesity	82,131 (21.6%)	66,641 (21.9%)	19,880 (22.0%)	181,419 (28.4%)	42,503 (16.8%)	25,372 (13.5%)	4,787 (31.6%)
Drug abuse	25,486 (6.7%)	16,135 (5.3%)	5,680 (6.3%)	29,164 (4.6%)	9,596 (3.8%)	4,512 (2.4%)	1,821 (12.0%)
Alcohol abuse	16,835 (4.4%)	15,447 (5.1%)	4,046 (4.5%)	22,737 (3.6%)	8,351 (3.3%)	3,863 (2.1%)	300 (2.0%)
Elixhauser comorbidity score, Median (IQR)							
Mortality score	0 (15)	2 (15)	2 (14)	15 (12)	3 (16)	4 (20)	-3 (7)
Readmission score	9 (12)	7 (10)	8 (13)	17 (11)	8 (10)	7 (10)	0 (5)

This study provides a brief overview of in-hospital mortality and length of stay to provide foundational context (Table 4.2). While in-hospital outcomes are not the main focus of this study, these descriptives highlight the importance of investigating relationship between individual ACSCs and sociodemographic factors. In the total study population, mortality rates for patients hospitalized with non-ACSCs and ACSCs were 2.7% and 1.4%, respectively. Among those who died in the hospital, 94.2% were hospitalized due to non-ACSCs, and 5.8% for ACSCs. Most admissions among those who died in the hospital from ACSCs were due to heart failure, representing 2.2% in the overall population and 54.4% in the subgroup of people hospitalized with ACSCs. Pneumonia followed as the subsequent leading cause, accounting for 2.01% in the overall population and 19.6% in the ACSC subgroup.

Table 4.2: In-hospital outcomes in the entire study population and within ACSCs groups

Type of hospitalizations	In-hospital mortality (%)		Length of hospital stay [median (IQR)]
	Underlying causes of admissions among those who died (%)	Mortality rate in the overall population (%)	
Non-ACSCs	94.2%	2.7%	3 (4)
ACSCs	5.8%	1.4%	3 (4)
1) Diabetes related complications	11.4%	0.8%	4 (4)
2) COPD/Asthma in older adults	10.3%	0.9%	3 (3)
3) Hypertension	1.0%	0.3%	2 (3)
4) Heart failure	54.4%	2.2%	4 (4)
5) Community acquired pneumonia	19.6%	2.0%	3 (3)
6) Urinary tract infection	3.2%	0.4%	3 (3)
7) Asthma in younger adults	0.2%	0.4%	2 (2)

4.3.2 Association between income, racial, and geographic factors, and individual ACSCs

Results of the multivariable multilevel logistic regression analyses, illustrating the associations both pre- and post-adjustment for all covariates have been presented in Table 4.3 and Appendix 19. The following sections describe the results of the analyses examining the factors associated with hospital admissions for each ACSC.

4.3.2.1 Association between race and hospitalizations due to individual ACSCs

Compared to the hospitalized individuals self-identified as White, those of Black had higher adjusted odds of admissions due to diabetes [OR 1.72, 95% CI 1.70-1.74], COPD [OR 1.33, 95% CI 1.31-1.34], adult asthma [OR 2.70, 95% CI 2.60-2.82], hypertension [OR 4.02, 95% CI 3.95-4.09], heart failure [OR 1.69, 95% CI 1.68-1.71], and UTI [OR 1.03, 95% CI 1.02-1.05] (Table 4.3). Although Black patients had lower unadjusted odds of COPD [OR 0.93, 95% CI 0.92-0.94] and UTI [OR 0.71, 95% CI 0.70-0.73] admissions comparing to White patients (Appendix 19), they increased after controlling for the covariates.

Table 4.3: Fully adjusted odds ratios [95% confidence intervals] and *P* values for exposures of interest (race, quartiles of median household income for patient's ZIP code, and hospital region) for each ACSC

Variables	Diabetes Related Complications	COPD in Elderly	Hypertension	Heart Failure	Community Acquired Pneumonia	UTI	Asthma in Younger Adults
Race							
White				*Reference Category*			
Black	1.72 [1.70-1.74] *p*<0.001	1.33 [1.31-1.34] *p*<0.001	4.02 [3.95-4.09] *p*<0.001	1.69 [1.68-1.71] *p*<0.001	0.92 [0.91-0.93] *p*<0.001	1.03 [1.02-1.05] *p*<0.001	2.70 [2.60-2.82] *p*<0.001
Hispanic	1.41 [1.40-1.43] *p*<0.001	0.93 [0.92-0.95] *p*<0.001	1.83 [1.79-1.88] *p*<0.001	1.15 [1.14-1.16] *p*<0.001	0.97 [0.96-0.99] *p*<0.05	1.19 [1.17-1.21] *p*<0.001	1.28 [1.21-1.34] *p*<0.001
Asian or Pacific Islander	0.83 [0.81-0.85] *p*<0.001	1.02 [0.99-1.06] *p*=0.14	1.90 [1.82-1.98] *p*<0.001	1.08 [1.06-1.10] *p*<0.001	0.97 [0.94-1.00] *p*=0.06	0.77 [0.74-0.80] *p*<0.001	0.70 [0.61-0.81] *p*<0.001
Native American	1.43 [1.38-1.48] *p*<0.001	0.91 [0.86-0.96] *p*<0.05	1.16 [1.05-1.28] *p*<0.05	0.89 [0.85-0.93] *p*<0.001	0.93 [0.88-0.98] *p*<0.05	1.05 [0.98-1.12] *p*=0.16	0.92 [0.74-1.13] *p*=0.42
Unspecified	1.04 [1.02-1.07] *p*<0.001	0.89 [0.86-0.91] *p*<0.001	1.71 [1.64-1.78] *p*<0.001	1.08 [1.06-1.10] *p*<0.001	0.94 [0.92-0.97] *p*<0.001	0.99 [0.96-1.02] *p*=0.63	1.13 [1.03-1.24] *p*<0.05
Median household income quartile for patient's ZIP Code							
Richest				*Reference Category*			
Second richest	1.17 [1.16-1.18] *p*<0.001	1.22 [1.20-1.23] *p*<0.001	1.14 [1.12-1.17] *p*<0.001	1.06 [1.05-1.07] *p*<0.001	1.07 [1.06-1.09] *p*<0.001	1.01 [1.00-1.03] *p*=0.12	1.09 [1.03-1.15] *p*<0.05
Second poorest	1.27 [1.26-1.29] *p*<0.001	1.36 [1.34-1.38] *p*<0.001	1.19 [1.16-1.22] *p*<0.001	1.08 [1.07-1.09] *p*<0.001	1.10 [1.08-1.11] *p*<0.001	1.02 [1.002-1.03] *p*<0.05	1.16 [1.09-1.23] *p*<0.001
Poorest	1.35 [1.34-1.37] *p*<0.001	1.59 [1.57-1.61] *p*<0.001	1.27 [1.24-1.30] *p*<0.001	1.12 [1.11-1.13] *p*<0.001	1.13 [1.11-1.15] *p*<0.001	1.08 [1.06-1.09] *p*<0.001	1.28 [1.21-1.36] *p*<0.001
Region of hospital							
Northeast				*Reference Category*			
Midwest	0.87 [0.84-0.89] *p*<0.001	0.74 [0.71-0.78] *p*<0.001	0.93 [0.89-0.97] *p*<0.05	0.83 [0.80-0.85] *p*<0.001	0.99 [0.95-1.04] *p*=0.81	0.94 [0.90-0.98] *p*<0.05	0.63 [0.58-0.68] *p*<0.001
South	1.05 [1.02-1.08] *p*<0.05	0.87 [0.84-0.92] *p*<0.001	1.12 [1.08-1.17] *p*<0.001	0.97 [0.94-0.99] *p*<0.05	1.11 [1.06-1.16] *p*<0.001	1.14 [1.10-1.18] *p*<0.001	0.58 [0.54-0.62] *p*<0.001
West	0.94 [0.92-0.97] *p*<0.001	0.64 [0.61-0.68] *p*<0.001	0.84 [0.81-0.88] *p*<0.001	0.86 [0.84-0.89] *p*<0.001	0.83 [0.79-0.87] *p*<0.001	0.79 [0.75-0.82] *p*<0.001	0.75 [0.70-0.82] *p*<0.001
Year							
2018				*Reference Category*			
2019	1.03 [1.02-1.04] *p*<0.001	0.95 [0.94-0.96] *p*<0.001	1.05 [1.03-1.07] *p*<0.001	1.00 [1.00-1.01] *p*=0.24	0.98 [0.97-0.99] *p*<0.05	0.98 [0.97-0.99] *p*<0.05	1.01 [0.97-1.06] *p*=0.57
2020	1.02 [1.01-1.03] *p*<0.001	0.63 [0.62-0.64] *p*<0.001	0.93 [0.92-0.95] *p*<0.001	0.88 [0.87-0.88] *p*<0.001	0.79 [0.78-0.79] *p*<0.001	0.83 [0.82-0.84] *p*<0.001	0.68 [0.65-0.71] *p*<0.001

Covariates							
Age	0.99 [0.98-0.99] *p*<0.001	1.03 [1.03-1.03] *p*<0.001	1.02 [1.02-1.02] *p*<0.001	1.04 [1.04-1.04] *p*<0.001	1.03 [1.03-1.03] *p*<0.001	1.04 [1.04-1.04] *p*<0.001	0.91 [0.91-0.91] *p*<0.001
Sex							
Female				*Reference Category*			
Male	2.15 [2.13-2.16] *p*<0.001	0.70 [0.70-0.71] *p*<0.001	1.05 [1.03-1.06] *p*<0.001	1.24 [1.23-1.25] *p*<0.001	1.01 [1.01-1.02] *p*<0.05	0.46 [0.46-0.47] *p*<0.001	1.41 [1.36-1.46] *p*<0.001
Hospital location/ teaching status	0.86 [0.86-0.87] *p*<0.001	0.70 [0.69-0.70] *p*<0.001	0.94 [0.93-0.95] *p*<0.001	0.81 [0.81-0.82] *p*<0.001	0.59 [0.59-0.60] *p*<0.001	0.72 [0.71-0.73] *p*<0.001	0.92 [0.89-0.95] *p*<0.001
Lifestyle factors							
Smoking history	1.06 [1.05-1.07] *p*<0.001	4.85 [4.81-4.89] *p*<0.001	1.14 [1.12-1.16] *p*<0.001	1.32 [1.31-1.33] *p*<0.001	1.67 [1.65-1.68] *p*<0.001	0.91 [0.90-0.92] *p*<0.001	2.77 [2.67-2.87] *p*<0.001
Obesity	1.02 [1.01-1.03] *p*<0.001	1.29 [1.28-1.30] *p*<0.001	1.19 [1.17-1.21] *p*<0.001	2.38 [2.37-2.40] *p*<0.001	1.01 [1.01-1.03] *p*<0.05	0.92 [0.90-0.93] *p*<0.001	2.01 [1.93-2.10] *p*<0.001
Drug abuse	0.39 [0.38-0.39] *p*<0.001	0.91 [0.89-0.93] *p*<0.001	0.90 [0.87-0.93] *p*<0.001	0.73 [0.72-0.74] *p*<0.001	0.80 [0.78-0.82] *p*<0.001	1.31 [1.27-1.35] *p*<0.001	1.23 [1.15-1.32] *p*<0.001
Alcohol abuse	0.43 [0.42-0.43] *p*<0.001	0.84 [0.83-0.86] *p*<0.001	0.70 [0.68-0.72] *p*<0.001	0.51 [0.50-0.51] *p*<0.001	0.58 [0.57-0.59] *p*<0.001	0.69 [0.67-0.71] *p*<0.001	0.37 [0.33-0.42] *p*<0.001
Elixhauser comorbidity score							
Mortality score	0.96 [0.96-0.96] *p*<0.001	0.98 [0.98-0.98] *p*<0.001	0.98 [0.98-0.98] *p*<0.001	0.99 [0.99-0.99] *p*<0.001	0.99 [0.99-0.99] *p*<0.001	1.01 [1.01-1.01] *p*<0.001	0.97 [0.97-0.97] *p*<0.001
Readmission score	1.09 [1.09-1.09] *p*<0.001	1.001 [1.001-1.002] *p*<0.001	1.03 [1.03-1.03] *p*<0.001	1.11 [1.11-1.11] *p*<0.001	1.03 [1.03-1.03] *p*<0.001	0.97 [0.97-0.98] *p*<0.001	0.93 [0.92-0.93] *p*<0.001
NIS hospital number; var (_cons)	0.07 [0.07-0.08]	0.23 [0.22-0.24]	0.11 [0.10-0.12]	0.10 [0.09-0.10]	0.22 [0.21-0.23]	0.13 [0.12-0.14]	0.26 [0.24-0.29]

Among the hospitalized Hispanic individuals, the unadjusted lower odds of admissions due to heart failure [OR 0.76, 95% CI 0.75-0.77], and UTI [OR 0.78, 95% CI 0.76-0.79] significantly increased when fully adjusted model was performed. Compared to patients of White race, this racial group had adjusted higher odds of admissions attributed to diabetes [OR 1.41, 95% CI 1.40-1.43], hypertension [OR 1.83, 95% CI 1.79-1.88], heart failure [OR: 1.15, 95% CI 1.14-1.16], adult asthma [OR 1.28, 95% CI 1.21-1.34], and UTI [OR 1.19, 95% CI 1.17-1.21] compared to White patients.

While comparing the patients of other minority groups with White race group, the study reported that patients of Asian or Pacific Islanders race group had higher adjusted odds of admissions due to hypertension [OR 1.90, 95% CI 1.82-1.98], and heart failure [OR 1.08, 95% CI 1.06-1.10]; Native American race group had higher adjusted odds of admissions due to diabetes [OR 1.43, 95% CI 1.38-1.48], and hypertension [OR 1.16, 95% CI 1.05-1.28]; other/ unspecified race groups had higher odds of diabetes [OR 1.04, 95% CI 1.02-1.07], hypertension [OR 1.71, 95% CI 1.64-1.78], heart failure [OR 1.08, 95% CI 1.06-1.10], and adult asthma [OR 1.13, 95% CI 1.03-1.24]. Additionally, compared to White patients, patients of Black [OR 0.92, 95% CI 0.91-0.93], Hispanic [OR 0.97, 95% CI 0.96-0.99], Native American [OR 0.93, 95% CI 0.88-0.98], and other [OR 0.94, 95% CI 0.92-0.97] race groups had lower adjusted odds of pneumonia admission.

4.3.2.2 Association between SES and hospitalizations due to individual ACSCs

Comparing to hospitalized individuals from the highest SES quartile, those of the lowest SES quartile had greater odds of admissions for diabetes [OR 1.35, 95% CI 1.34-1.37], COPD [OR 1.59, 95% CI 1.57-1.61], hypertension [OR 1.27, 95% CI 1.24-1.30], heart failure [OR 1.12, 95% CI 1.11-1.13], CAP [OR 1.13, 95% CI 1.11-1.15], UTI [OR 1.08, 95% CI 1.06-1.09], and adult asthma [OR 1.28, 95% CI 1.21-1.36]. Similarly, patients of second lowest, and second highest SES quartiles had higher odds of admissions due to all conditions comparing with those of the highest SES quartile. However, the odds of UTI admissions among patients of second highest SES quartile [OR 1.01, 95% CI 1.00-1.03] compared to patients of the highest SES quartile did not have statistical significance.

4.3.2.3 Association between regions and hospitalizations due to individual ACSCs

Compared to the patients from the Northeast census region, those hospitalized in the Southern region had higher odds of diabetes related complications [OR 1.05, 95% CI 1.02-1.08], hypertension [OR 1.12, 95% CI 1.08-1.17], CAP [OR 1.11, 95% CI 1.06-1.16], and UTI [OR 1.14, 95% CI 1.10-1.18] admissions. Conversely, patients admitted into the hospitals located in the West and Midwest regions had consistently lower odds of admissions for all ACSCs compared to those of the Northeast region. Although, the Midwest region had higher unadjusted odds of admission due to community acquired pneumonia (Appendix 19), the association was not statistically significant after adjusting for the covariates and confounding variables [unadjusted OR 1.17, 95% CI 1.16-1.18; adjusted OR 0.99, 95% CI 0.95-1.04].

The additional multinomial regression analysis conducted in this study, provided us similar results to the findings discussed above (Appendix 20).

4.4 Discussion

In this contemporary study using a nationally representative database, we observed a significant association between racial, socioeconomic, and geographic factors and hospitalizations for each type of ACSC. Compared to the patients from White race group, patients of Black, and Hispanic ethnicity had higher odds of hospitalizations for majority of the ACSCs. The likelihood of hospital admissions due to any of the ACSCs were higher among patients from the lowest and second lowest SES quartiles compared to those from the highest income quartile. Compared to the Northeast census region, hospitals located in the South had higher odds of admissions due to most of the ACSCs, while hospitals in the Midwest and West demonstrated a consistently lower odds for these admissions.

4.4.1 Association of race and individual ACSCs

Among the seven ACSCs studied, we found that hospitalized Black and Hispanic individuals had higher odds of hospital admissions for six and five ACSCs, respectively, compared to those of White individuals. Patients from Asian or Pacific Islander, Native American, and other racial/ ethnic backgrounds were also associated with higher odds of

hospitalizations for some of the ACSCs compared to those from White race group. These findings reflect prior studies that have found significant variation in admissions individually for diabetes and related complications (5,16,23,98,118,153,160,195,196), hypertension (16,24,153,160,196), heart failure (16,28,153,160,196-200), COPD (153,201,202), adult asthma (16,26,153,161,196), and UTI (118,202,203) among people of BIPOC community compared to White race group. Additionally, our study observed that hospitalized White individuals had a higher likelihood of pneumonia admissions, which is consistent with previous studies (16,43,65,204). However, contrasting our results, previous studies have reported lower association of Black race and COPD admissions (16,65). This could partly be explained by heterogeneity between studies. For example, sample of both studies included ≥ 65 years old age group only (16,65). Moreover, O'Neil et al., 2010 restricted the investigation to specific geographic location (16).

These findings might be influenced by various factors. Existing literature has identified limited access to quality outpatient care as an important determinant of racial differences across all types of ACSCs (24,157,160-162). A systematic review aimed to understand patient perspectives on determinants of ACSCs hospitalizations identified several barriers to accessing primary healthcare such as financial constraints, lack of transportation, and limited after-hours service availability (58). Other identified issues were insufficient knowledge about specific health conditions, diverse health beliefs and behaviors, and low prioritization of disease management (58). Further, racial disparities in healthcare quality, particularly through residential segregation, was examined by Chan et al., 2012 (212). Their study found that despite having accessible primary care, Black and Hispanic people in segregated communities who were diabetic, received fewer recommended services and faced more challenges in consulting specialists compared to diabetic White individuals (212).

4.4.2 Association of SES and individual ACSCs

Our study reported higher odds of hospitalizations for ACSCs among patients of the lowest and lower income quartiles compared to those of the highest income quartile. This association persisted across all examined ACSCs, with the most pronounced effects

observed in COPD, adult asthma, and diabetes. Our findings are consistent with previous research that identified similar association between SES groups and hospitalizations due to diabetes (124,125,154,213-215), hypertension (154,214,216), heart failure (123,154,214,217,218), COPD (25,154,215,221,222), adult asthma (25,154), pneumonia (154,223,224), and UTI (154,225). Our analyses revealed a clear income gradient in the likelihood of ACSCs admissions across SES quartiles, with this trend being more pronounced for chronic ACSCs. This underlines the significant influence of socioeconomic factors on health outcomes and the necessity of addressing these disparities in healthcare policy and practice.

Diverse factors may underlie the observed socioeconomic variations in ACSCs hospitalizations. Inadequate access to primary healthcare, particularly due to insufficient health insurance, has been identified as significant contributor to socioeconomic disparities (20,57,152,226). Studies conducted at neighbourhood level reported higher rates of hospital admissions due to ACSCs in economically deprived regions comparing with the wealthiest ones despite having primary care access (25). The observed difference might be attributed to the perceived higher quality of hospital care and ease of access (167). Prior research also highlighted that higher rates of ACSCs admissions among low SES groups could be possibly explained by chronic health conditions and its inadequate management (154). Bluestein et al., 1998 has stated that increased burden of chronic illness and lifelong poor health among individuals with low socioeconomic status increase their susceptibility to ACSCs hospitalizations (20). While our analysis controlled for Elixhauser comorbidity scores, we found that the influence of chronic health conditions on ACSCs remained significant. Sentell et al., 2016 identified several factors explaining association between low-income groups and increased hospitalizations for ACSCs, which included health literacy, lack of transportation, and insufficient disease management knowledge at home (57). These findings underscore the multifaceted nature of healthcare disparities and highlight the need for a comprehensive approach to address them.

4.4.3 Association of regions and individual ACSCs

Consistent with previous research, we found higher likelihood of admissions in the South census region compared to the Northeast for several ACSCs including diabetes (21,22), hypertension (22,24), pneumonia (22,172), and UTI (22). Previous research reported higher admissions for COPD (21,131), heart failure (29,130), and asthma (26,172); however, our results did not reflect these findings. This lack of significant association could possibly be explained by the use of large geographic units which can obscure underlying geographic disparities, potentially becoming more evident when examining smaller geographic units (24).

Such geographic differences might be described by several factors. Research suggests that inadequate access to primary care (3,29,175) and variations in the number and practice patterns of physicians across areas (219,232) are important contributors to such disparities. In reference to availability of primary care physicians, travel time in seeking primary care has been identified as an important factor by prior research in relation to ACSCs admissions (173). Several factors influencing geographic variations in ACSCs admission rates were identified by a systematic review such as easy accessibility of secondary care, higher availability of hospital beds, and hospital staffing levels (175). Additionally, variation in the coding of diagnoses across regions could partly explain these disparities (172)

4.4.4 Implications

This study highlights the greater likelihood of ACSCs hospitalizations among BIPOC individuals and low-SES groups, emphasizing the need for targeted interventions to enhance primary care access and quality for these populations (219). Tailoring care to address substantial disparities, especially in chronic conditions, can effectively mitigate the risks associated with hospitalization (234). Moreover, the observed regional disparities in this context call for the establishment of area-based health enhancement strategies, ensuring sufficient supply of healthcare personnel and continuity of care. Efficient system-level interventions such as combining patient education, improved healthcare communication, continuous care, expanded insurance coverage, and strengthening provider capacity are essential to reduce ACSCs hospitalizations and address racial and ethnic healthcare disparities (51,220). Moreover, ensuring effective

management of healthcare resources is critical to balancing care demand and preventing unnecessary admissions (219).

4.4.5 Strengths and limitations

This study has several strengths. Firstly, the study used nationally representative data on hospitalized patients. Secondly, this study used the most current list and definitions of ACSCs released in 2022 by AHRQ to comprehensively identify all conditions. Furthermore, the study used data from multiple years of NIS, including the most recent fiscal year available at the time of analysis, making the findings relevant to the current policy context.

However, there are some limitations in the study. Firstly, the NIS dataset records multiple admissions for a single individual within the same year as distinct occurrences; however, due to the data being deidentified, it is not possible to account for the correlation among multiple admissions in the analysis. Secondly, this analysis used data on patients who were admitted in hospital; however, the decision to seek hospital care and be admitted may not be randomly distributed in the population. In our study, SES was solely defined by the median income of the patient's ZIP code. Nevertheless, this is common in research based on health administrative data that does not include individual-level income information (15,44). Another limitation relates to data on race which is based on self-identification. While this approach is considered most reliable, mis-categorization of racial information is not uncommon in administrative data (158,170). Moreover, the NIS data includes large racial categories, such as Black and White race. Although this is commonly used in literature, it ignores significant heterogeneity within each racial group. While interpreting the findings of this study, it is important to acknowledge the potential impact of multiple testing, which relates to testing multiple hypothesis simultaneously within a regression analysis, resulting in some associations being significant by chance alone. While a number of approaches, including Bonferroni correction, have been proposed, they are unlikely to have changed the statistical significance in our regression analysis. Finally, despite controlling for possible confounders, it's crucial to note that residual confounding may still affect this study.

4.5 Conclusion

This study reveals that race, socioeconomic status, and geographic locations are important determinants of ACSCs hospital admissions. It emphasizes the significant association of Black, Hispanic, and other minority race groups, low SES, and the South census region with ACSCs hospitalizations especially for chronic conditions like hypertension, diabetes, COPD, and adult asthma. These findings underscore the need for targeted, condition-specific strategies and policy interventions that specifically address the disparities in these communities. This study recommends comprehensive qualitative research focusing on the areas showing disparities in hospital admissions for individual ACSCs. It should prioritize understanding the barriers to healthcare access, exploring communication dynamics between patients and providers, and the influence of local health policies on patient outcomes. Future research should aim to provide actionable insight for healthcare providers and policymakers, guiding the development of condition-specific interventions, tailored healthcare services and policy reforms.

Chapter 5

5 Integrated Summary and Conclusion

This chapter presents a comprehensive summary and integration of the findings from the two papers featured in this thesis. It will discuss the implications and constraints of these findings as well as potential avenues for future research in this field.

5.1. Thesis goal

Existing literature reports significant variation among race, SES, geographic location, age, and sex groups in avoidable hospitalizations due to ACSCs (15-17,20-22,42). In addition to overall PAH, these disparities were reported for different types of ACSCs separately as well (130,25,44,118,123-125). Although existing literature is abundant, it is limited in terms of the study sample inclusion criteria based on age (15,16,27,41,44), isolated region (15,16,27,42,43,147,148), single race group (17), single ACSC (23-25,28,29,130,131). Furthermore, there has been a paucity of research that specifically addresses this aspect incorporating recent data from multiple years (16,18,98,153). The present analyses addressed existing gaps by including a broader study sample by using contemporary, multi-year nationally representative data.

The aim of the thesis was to examine the association of sociodemographic factors on Potentially Avoidable Hospitalizations (PAH) as well as to investigate the association of the racial/ ethnic, socioeconomic, and geographic determinants with hospital admissions for each type of Ambulatory Care Sensitive Conditions (ACSCs) among adult hospitalized patients in the US. Utilizing the Nationwide Inpatient Sample database, the determinants of overall PAH were identified (Chapter 3). In light of findings obtained from the first analysis, the associations between the social factors and individual ACSCs were investigated utilizing the same data (Chapter 4).

5.2 Summary of studies

5.2.1 Association between sociodemographic factors and potentially avoidable hospitalizations

The current study performed multivariable multilevel logistic regression models to understand the association between race, SES, geographic location, age, and sex as well as PAH among 17.6 million hospitalized patients in the US between 2018 and 2020. The findings of the analyses suggested that hospitalized Black, Hispanic, and patients from unspecified race groups had greater odds of PAH compared to those from White race group. Furthermore, hospitalized patients belonging to the lowest income quartile had higher odds of PAH than those from highest income quartile. Admissions into the hospitals located in the South had the higher likelihood to be PAH when compared to those located in the Northeast. Finally, older age as well as male sex had higher odds of such hospital admissions. Both individual and hospital-level factors including accessing quality primary health care, supply of healthcare providers, patient education, hospital resource allocation, patient comorbidities continue to drive disparities in various social determinants of heath in PAH.

5.2.2 Association between race, SES, and geographic location, and different types of Ambulatory Care Sensitive Conditions

The present study conducted multilevel logistic regression analyses to understand potential associations between race, SES, and geographic location, and each type of ACSC. Several important findings came out of these analyses. In contrast to hospitalized White individuals, patients self-reported as Black had higher odds of hospital admission attributed to all ACSCs except pneumonia, and patients self-reported as Hispanic had higher odds for all ACSCs except COPD, and pneumonia. Compared to White patients, varying degree of difference in odds of ACSCs hospitalizations were also observed among patients of other race groups as well. In terms of SES, patients belonging to lower and the lowest SES quartiles showed higher odds consistently for each of the ACSCs compared to those from highest SES quartile. In terms of geographic location, higher odds of admissions into the hospitals located in the South were observed for diabetes, hypertension, pneumonia, and UTI when compared to the Northeast region.

This study also reported that the odds of experiencing avoidable hospital admissions across racial/ ethnic groups were more pronounced for chronic ACSCs, especially hypertension, diabetes, as well as adult asthma and this was observed particularly among

Black and Hispanic patients. Patients identified as White had higher likelihood to have a hospital admission for CAP. For the patients of low-SES groups, the odds were greater for COPD, diabetes, and adult asthma.

5.3 Strengths and limitations

This study has several strengths. Firstly, the study used nationally representative data on hospitalized patients. Secondly, this study used the most current list and definitions of ACSCs released in 2022 by AHRQ to comprehensively identify all conditions. Furthermore, the study used data from multiple years of NIS, including the most recent fiscal year available at the time of analysis, making the findings relevant to the current policy context.

However, there are some limitations in this study. The NIS dataset records multiple admissions for a single individual within the same year as distinct occurrences; however, due to the data being deidentified, it is not possible to account for the correlation among multiple admissions in the analysis. Secondly, in our study, SES was solely defined by the median income of the patient's ZIP code. Nevertheless, this is common in research based on health administrative data that does not include individual-level income information (15,44). Another limitation relates to data on race which is based on self-identification. While this approach is considered most reliable, mis-categorization of racial information is not uncommon in administrative data (158,170). Moreover, the NIS data includes large racial categories, such as Black and White race. While this is commonly used in literature, it ignores significant heterogeneity within each racial group. This analysis used data on patients who were admitted in hospital; however, the decision to seek hospital care and be admitted may not be randomly distributed in the population.

In our regression model, we incorporated several comorbidities along with comorbidity scores; notably, some of these comorbidities are also included in our outcome variable as ACSCs. However, it should be noted that the dependent variable in our study is not the presence of ACSCs but rather the incidence of hospitalizations attributed to any of the ACSCs. Moreover, while adjusting for Elixhauser comorbidity score enables us to control for the overall severity of an individual’s health condition, it does not allow adjustment

for specific conditions diagnosed as secondary (i.e. different to the primary cause of ACSC admission). In terms of our analysis of the interaction with the pandemic period, the time frame used in our analysis has limitations. Although the pandemic was officially declared in March 2020, the pandemic year in our analysis includes patients hospitalized in January and February 2020 because of the annual nature of NIS data. As a result, the observed change in the association between sociodemographic factors and PAH may not be generalizable to the pandemic period. Additionally, while interpreting the findings of this study, it is important to acknowledge the potential impact of multiple testing, which relates to the association between each individual ACSC and social factors. While a number of approaches, including Bonferroni correction, have been proposed, they are unlikely to have changed the statistical significance in our regression analysis. Finally, despite controlling for possible confounders, it's crucial to note that residual confounding may still affect this study.

5.4 Implications and future directions

The findings of the research highlight disparities in potentially avoidable hospital admissions for ACSCs and offers valuable insights regarding crucial health equity issues. The persistent nature of these disparities, despite recognition and federal efforts, suggests that more targeted actions are required (235). It advocates for comprehensive system-level interventions that include patient education, enhanced healthcare communication, expanded insurance coverage, continuous care, and reinforced healthcare provider capacity, aimed at reducing preventable hospitalizations and tackling racial and ethnic disparities in healthcare (51,220). Alongside, measures should be taken to ensure effective allocation of healthcare resources, and this should be sensitive to the areas exhibiting pronounced disparities in ACSC hospitalizations (219).

The findings of this thesis pave the way for several potential avenues in future research. Conducting comprehensive qualitative research is recommended to explore individual experiences and perceptions about healthcare barriers. In-depth interviews or focus groups with individuals from the underserved socioeconomic and racial groups as well as primary care physicians across regions showing disparities may yield actionable insights

for healthcare providers and policymakers, guiding the development of targeted healthcare strategies and policy reforms.

Further quantitative research may help understand the role of different health policies and interventions at the national level. In such studies, analyzing data across different time points may allow for an assessment of the long-term effectiveness of policy changes and healthcare interventions. Finally, for a more precise investigation of regional disparities, focusing on smaller geographic units is recommended.

5.5 Conclusions

This study aimed to analyze the association of sociodemographic factors with Potentially Avoidable Hospitalizations (PAH) and to examine the association of social factors with each type of Ambulatory Care Sensitive Conditions (ACSCs) among adult hospitalized patients in the US by adjusting for potential confounders and covariates. The findings revealed that patients self-identified as Black or Hispanic, and belonging to lower socioeconomic groups had higher odds of hospital admissions being avoidable due to ACSCs compared to those of White race group and belonged to the highest socioeconomic group. Geographically, hospitals in the South were more likely to have PAH than those in the Northeast. These associations remain significant while analyzing hospital admissions for each type of ACSCs and they were observed to be more pronounced for chronic conditions especially for hypertension, diabetes, COPD, and asthma.

These findings underscore the need for focused interventions, especially for chronic ACSCs, and healthcare strategies that specifically address the disparities in these communities. Comprehensive qualitative research is recommended to help develop tailored healthcare services and policy reforms aimed to reduce potentially avoidable hospitalizations and to promote equitable health outcomes in disproportionately affected communities.

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Appendices

Appendix 1: AHRQ Definitions of Ambulatory Care Sensitive Conditions

ACSCs		Definitions
Diabetes related complica-tions	Diabetes Short-Term Complications [a]	Hospital discharges for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for diabetes with short-term complications i.e., ketoacidosis, hyperosmolarity, or coma.
	Diabetes Long-Term Complications [a]	Hospital discharges for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for diabetes with long-term complications i.e., renal, eye, neurological, circulatory, other specified, or unspecified.
	Uncontrolled Diabetes [a]	Hospital discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for uncontrolled diabetes without mention of a short-term or long-term complication.
	Lower-Extremity Amputation Among Patients with Diabetes [b]	Hospital discharges for patients ages 18 years and older, with any listed ICD-10-PCS procedure code for lower-extremity amputation and any listed ICD-10-CM diagnosis code for diabetes.
Hypertension [c]		Hospital discharges for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for hypertension.
Heart Failure [d]		Hospital discharges for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for heart failure.
COPD or Asthma in Older Adults [e]		Hospital discharges for patients ages 40 years and older, with either • a principal ICD-10-CM diagnosis code for COPD (excluding acute bronchitis) or • a principal ICD-10-CM diagnosis code for asthma.
Asthma in Younger Adults [e]		Hospital discharges for patients ages 18 through 39 years, with a principal ICD-10-CM diagnosis code for asthma.
Community Acquired Pneumonia [f]		Hospital discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for community acquired pneumonia.
Urinary Tract Infection [g]		Hospital discharges, for patients ages 18 years and older, with a principal ICD-10-CM diagnosis code for urinary tract infection.

[a] Excludes obstetric hospitalizations and transfers from other institutions.
[b] Excludes traumatic lower extremity amputation hospitalizations, obstetric hospitalizations, and transfers from other institutions.
[c] Excludes hospitalizations with stage 1-4 or unspecified chronic kidney disease combined with a dialysis access procedure, hospitalizations for cardiac procedure, obstetric hospitalizations, and transfers from other institutions.
[d] Excludes hospitalizations with cardiac procedure, obstetric hospitalizations, and transfers from other institutions.
[e] Excludes hospitalizations with cystic fibrosis and anomalies of the respiratory system, obstetric hospitalizations, and transfers from other institutions.
[f] Excludes hospitalizations with sickle cell, hemoglobin-S disease admissions, other indications of immunocompromised state, obstetric hospitalizations, and transfers from other institutions.
[g] Excludes hospitalizations with a kidney or urinary tract disorder, hospitalizations with other indications of immunocompromised state, obstetric hospitalizations, and transfers from other institutions.

Appendix 2: ICD-10 codes for Ambulatory Care Sensitive Conditions

ACSCs		ICD-10-CM codes
Diabetes Short-Term Complications		E1010, E1101, E1011, E1110, E10641, E1111, E1100, E11641
Diabetes Long-Term Complications		E1021, E1022, E1029, E10311, E10319, E10321, E103211, E103212, E103213, E103219, E10329, E103291, E103292, E103293, E103299, E1121, E1122, E1129, E11311, E11319, E11321, E113211, E113212, E113213, E113219, E11329, E113291, E113292, E113293, E113299, E10331, E103311, E103312, E103313, E103319, E10339, E103391, E103392, E103393, E103399, E10341, E103411, E11331, E113311, E113312, E113313, E113319, E11339, E113391, E113392, E113393, E113399, E11341, E113411, E103412, E103413, E103419, E10349, E103491, E103492, E103493, E103499, E10351, E103511, E103512, E103513, E103519, E103521, E113412, E113413, E113419, E11349, E113491, E113492, E113493, E113499, E11351, E113511, E113512, E113513, E113519, E113521, E103522, E103523, E103529, E103531, E103532, E103533, E103539, E103541, E103542, E103543, E113522, E113523, E113529, E113531, E113532, E113533, E113539, E113541, E113542, E113543, E103549, E103551, E103552, E103553, E103559, E10359, E103591, E103592, E103593, E103599, E1036, E1037X1, E1037X2, E1037X3, E113549, E113551, E113552, E113553, E113559, E11359, E113591, E113592, E113593, E113599, E1136, E1137X1, E1137X2, E1137X3, E1037X9, E1039, E1040, E1041, E1042, E1043, E1044, E1049, E1051, E1052, E1059, E10610, E10618, E10620, E10621, E10622, E10628, E10630, E10638, E1069, E108, E1137X9, E1139, E1140, E1141, E1142, E1143, E1144, E1149, E1151, E1152, E1159, E11610, E11618, E11620, E11621, E11622, E11628, E11630, E11638, E1169, E118
Uncontrolled Diabetes		E10649, E11649, E1065, E1165
Lower-Extremity Amputation Among Patients with Diabetes	ICD-10-PCS procedure code for lower-extremity amputation	0Y620ZZ, 0Y630ZZ, 0Y640ZZ, 0Y670ZZ, 0Y680ZZ, 0Y6C0Z1, 0Y6C0Z2, 0Y6C0Z3, 0Y6D0Z1, 0Y6D0Z2, 0Y6D0Z3, 0Y6F0ZZ, 0Y6G0ZZ, 0Y6H0Z1, 0Y6H0Z2, 0Y6H0Z3, 0Y6J0Z1, 0Y6J0Z2, 0Y6J0Z3, 0Y6M0Z0, 0Y6M0Z4, 0Y6M0Z5, 0Y6M0Z6, 0Y6M0Z7, 0Y6M0Z8, 0Y6M0Z9, 0Y6M0ZB, 0Y6M0ZC, 0Y6M0ZD, 0Y6M0ZF, 0Y6N0Z0, 0Y6N0Z4, 0Y6N0Z5, 0Y6N0Z6, 0Y6N0Z7,

		0Y6N0Z8, 0Y6N0Z9, 0Y6N0ZB, 0Y6N0ZC, 0Y6N0ZD, 0Y6N0ZF
	ICD-10-CM diagnosis code for diabetes	E1010, E1011, E1021, E1022, E1029, E10311, E10319, E10321, E103211, E103212, E113531, E113532, E113533, E113539, E113541, E113542, E113543, E113549, E113551, E113552, E103213, E103219, E10329, E103291, E103292, E103293, E103299, E10331, E103311, E103312, E103313, E103319, E10339, E113553, E113559, E11359, E113591, E113592, E113593, E113599, E1136, E1137X1, E1137X2, E1137X3, E1137X9, E1139, E103391, E103392, E103393, E103399, E10341, E103411, E103412, E103413, E103419, E10349, E103491, E103492, E103493, E1140, E1141, E1142, E1143, E1144, E1149, E1151, E1152, E1159, E11610, E11618, E11620, E11621, E103499, E10351, E103511, E103512, E103513, E103519, E103521, E103522, E103523, E103529, E103531, E103532, E11622, E11628, E11630, E11638, E11641, E11649, E1165, E1169, E118, E119, E1300, E1301, E103533, E103539, E103541, E103542, E103543, E103549, E103551, E103552, E103553, E103559, E10359, E1310, E1311, E1321, E1322, E1329, E13311, E13319, E13321, E133211, E133212, E133213, E1042, E1043, E1044, E1049, E1051, E1052, E1059, E10610, E10618, E10620, E10621, E10622, E133391, E133392, E133393, E133399, E13341, E133411, E133412, E133413, E133419, E13349, E133491, E133492, E10628, E10630, E10638, E10641, E10649, E1065, E1069, E108, E109, E1100, E1101, E1110, E133493, E133499, E13351, E133511, E133512, E133513, E133519, E133521, E133522, E133523, E133529, E133531, E1111, E1121, E1122, E1129, E11311, E11319, E11321, E113211, E113212, E113213, E113219, E133532, E133533, E133539, E133541, E133542, E133543, E133549, E133551, E133552, E133553, E133559, E103591, E103592, E103593, E103599, E1036, E1037X1, E1037X2, E1037X3, E1037X9, E1039, E1040, E1041, E133219, E13329, E133291, E133292, E133293, E133299, E13331, E133311, E133312, E133313, E133319, E13339, E11329, E113291, E113292, E113293, E113299, E11331, E113311, E113312, E113313, E113319, E11339, E113391, E113392, E13359, E133591, E133592, E133593, E133599, E1336, E1337X1, E1337X2, E1337X3, E1337X9, E1339, E1340, E1341,

		E113393, E113399, E11341, E113411, E113412, E113413, E113419, E11349, E113491, E113492, E113493, E113499, E11351, E113511, E1342, E1343, E1344, E1349, E1351, E1352, E1359, E13610, E13618, E13620, E13621, E13622, E13628, E13630, E113512, E113513, E113519, E113521, E113522, E113523, E113529, E13638, E13641, E13649, E1365, E1369, E138, E139
Hypertension		I10, I119, I160, I161, I129, I169, I1310
Heart Failure		I0981, I5041, I110, I5042, I130, I5043, I132, I50810, I501, I50811, I5020, I50812, I5021, I50813, I5022, I50814, I5023, I5082, I5030, I5083, I5031, I5084, I5032, I5089, I5033, I509, I5040
COPD or Asthma in Older Adults	COPD	J410, J439, J411, J440, J418, J441, J42, J449, J430, J470, J431, J471, J432, J479, J438
	Asthma	J4521, J4552, J4522, J45901, J4531, J45902, J4532, J45990, J4541, J45991, J4542, J45998, J4551
Asthma in Younger Adults		J4521, J4552, J4522, J45901, J4531, J45902, J4532, J45990, J4541, J45991, J4542, J45998, J4551
Community Acquired Pneumonia		J13, J159, J14, J160, J15211, J168, J15212, J180, J153, J181, J154, J188, J157, J189
Urinary Tract Infection		N10, N2886, N12, N3000, N3001, N151, N159, N3090, N16, N3091, N2884, N2885, N390

Appendix 3: Primary exposure variable definitions

Race	1 = White
	2 = Black
	3 = Hispanic
	4 = Asian or Pacific Islander
	5 = Native American
	6 = Other/ unspecified
Median household income for patient's ZIP Code	1 = 0 – 25th percentile (poorest)
	2 = 26th – 50th percentile (second poorest)
	3 = 51st – 75th percentile (second richest)
	4 = 76th – 100th percentile (richest)
Hospital census region	1 = Northeast
	2 = Midwest
	3 = South
	4 = West
Age	18 - 90 years
Sex	0 = Male
	1 = Female

Appendix 4: ICD-10 codes for select Elixhauser comorbid conditions used in the analyses

Conditions	ICD-10-CM Codes
Diabetes with chronic complications	E0821, E0822, E0829, E08311, E08319, E08321, E083211, E083212, E083213, E083219, E08329, E083291, E083292, E083293, E083299, E08331, E083311, E083312, E083313, E083319, E08339, E083391, E083392, E083393, E083399, E08341, E083411, E083412, E083413, E083419, E08349, E083491, E083492, E083493, E083499, E08351, E083511, E083512, E083513, E083519, E083521, E083522, E083523, E083529, E083531, E083532, E083533, E083539, E083541, E083542, E083543, E083549, E083551, E083552, E083553, E083559, E08359, E083591, E083592, E083593, E083599, E0836, E0837X1, E0837X2, E0837X3, E0837X9, E0839, E0840, E0841, E0842, E0843, E0844, E0849, E0851, E0852, E0859, E08610, E08618, E08620, E08621, E08622, E08628, E08630, E08638, E08641, E08649, E0865, E0869, E088, E0921, E0922, E0929, E09311, E09319, E09321, E093211, E093212, E093213, E093219, E09329, E093291, E093292, E093293, E093299, E09331, E093311, E093312, E093313, E093319, E09339, E093391, E093392, E093393, E093399, E09341, E093411, E093412, E093413, E093419, E09349, E093491, E093492, E093493, E093499, E09351, E093511, E093512, E093513, E093519, E093521, E093522, E093523, E093529, E093531, E093532, E093533, E093539, E093541, E093542, E093543, E093549, E093551, E093552, E093553, E093559, E09359, E093591, E093592, E093593, E093599, E0936, E0937X1, E0937X2, E0937X3, E0937X9, E0939, E0940, E0941, E0942, E0943, E0944, E0949, E0951, E0952, E0959, E09610, E09618, E09620, E09621, E09622, E09628, E09630, E09638, E09641, E09649, E0965, E0969, E098, E1021, E1022, E1029, E10311, E10319, E10321, E103211, E103212, E103213, E103219, E10329, E103291, E103292, E103293, E103299, E10331, E103311, E103312, E103313, E103319, E10339, E103391, E103392, E103393, E103399, E10341, E103411, E103412, E103413, E103419, E10349, E103491, E103492, E103493, E103499, E10351, E103511, E103512, E103513, E103519, E103521, E103522, E103523, E103529, E103531, E103532, E103533, E103539, E103541, E103542, E103543, E103549, E103551, E103552, E103553, E103559, E10359, E103591, E103592, E103593, E103599, E1036, E1037X1, E1037X2, E1037X3, E1037X9, E1039, E1040, E1041, E1042, E1043, E1044, E1049, E1051, E1052, E1059, E10610, E10618, E10620, E10621, E10622, E10628, E10630, E10638, E10641, E10649, E1065, E1069, E108, E1121, E1122, E1129, E11311, E11319, E11321, E113211, E113212, E113213, E113219, E11329, E113291, E113292, E113293, E113299, E11331,

	E113311, E113312, E113313, E113319, E11339, E113391, E113392, E113393, E113399, E11341, E113411, E113412, E113413, E113419, E11349, E113491, E113492, E113493, E113499, E11351, E113511, E113512, E113513, E113519, E113521, E113522, E113523, E113529, E113531, E113532, E113533, E113539, E113541, E113542, E113543, E113549, E113551, E113552, E113553, E113559, E11359, E113591, E113592, E113593, E113599, E1136, E1137X1, E1137X2, E1137X3, E1137X9, E1139, E1140, E1141, E1142, E1143, E1144, E1149, E1151, E1152, E1159, E11610, E11618, E11620, E11621, E11622, E11628, E11630, E11638, E11641, E11649, E1165, E1169, E118, E1321, E1322, E1329, E13311, E13319, E13321, E133211, E133212, E133213, E133219, E13329, E133291, E133292, E133293, E133299, E13331, E133311, E133312, E133313, E133319, E13339, E133391, E133392, E133393, E133399, E13341, E133411, E133412, E133413, E133419, E13349, E133491, E133492, E133493, E133499, E13351, E133511, E133512, E133513, E133519, E133521, E133522, E133523, E133529, E133531, E133532, E133533, E133539, E133541, E133542, E133543, E133549, E133551, E133552, E133553, E133559, E13359, E133591, E133592, E133593, E133599, E1336, E1337X1, E1337X2, E1337X3, E1337X9, E1339, E1340, E1341, E1342, E1343, E1344, E1349, E1351, E1352, E1359, E13610, E13618, E13620, E13621, E13622, E13628, E13630, E13638, E13641, E13649, E1365, E1369, E138
Diabetes without chronic complications	E0800, E0801, E0810, E0811, E089, E0900, E0901, E0910, E0911, E099, E1010, E1011, E109, E1100, E1101, E1110, E1111, E119, E1300, E1301, E1310, E1311, E139, O24011, O24012, O24013, O24019, O2402, O2403, O24111, O24112, O24113, O24119, O2412, O2413, O24311, O24312, O24313, O24319, O2432, O2433, O24410, O24414, O24415, O24419, O24420, O24424, O24425, O24429, O24430, O24434, O24435, O24439, O24811, O24812, O24813, O24819, O2482, O2483, O24911, O24912, O24913, O24919, O2492, O2493
Hypertension, uncomplicated	I10, I160, I169, O10011, O10012, O10013, O10019, O1002, O1003
Hypertension, complicated	H35031, H35032, H35033, H35039, I119, I129, I1310, I150, I151, I152, I158, I159, I161, I674, O10111, O10112, O10113, O10119, O1012, O1013, O10211, O10212, O10213, O10219, O1022, O1023, O10311, O10312, O10313, O10319, O1032, O1033, O10411, O10412, O10413, O10419, O1042, O1043, O10911, O10912, O10913, O10919, O1092, O1093, O111, O112, O113, O114, O115, O119, O161, O162, O163, O164, O165, O169, I120, I1311

Heart failure	I0981, I501, I5020, I5021, I5022, I5023, I5030, I5031, I5032, I5033, I5040, I5041, I5042, I5043, I50810, I50811, I50812, I50813, I50814, I5082, I5083, I5084, I5089, I509, I5181, I97130, I97131, O29121, O29122, O29123, O29129, R570, Z95811, Z95812, I110, I130, I132
Cerebrovascular disease	G450, G451, G452, G453, G454, G458, G459, G460, G461, G462, G463, G464, G465, G466, G467, G468, H3400, H3401, H3402, H3403, H3410, H3411, H3412, H3413, H34211, H34212, H34213, H34219, H34231, H34232, H34233, H34239, I6000, I6001, I6002, I6010, I6011, I6012, I602, I6020, I6021, I6022, I6030, I6031, I6032, I604, I6050, I6051, I6052, I606, I607, I608, I609, I610, I611, I612, I613, I614, I615, I616, I618, I619, I6200, I6203, I621, I629, I6300, I63011, I63012, I63013, I63019, I6302, I63031, I63032, I63033, I63039, I6309, I6310, I63111, I63112, I63113, I63119, I6312, I63131, I63132, I63133, I63139, I6319, I6320, I63211, I63212, I63213, I63219, I6322, I63231, I63232, I63233, I63239, I6329, I6330, I63311, I63312, I63313, I63319, I63321, I63322, I63323, I63329, I63331, I63332, I63333, I63339, I63341, I63342, I63343, I63349, I6339, I6340, I63411, I63412, I63413, I63419, I63421, I63422, I63423, I63429, I63431, I63432, I63433, I63439, I63441, I63442, I63443, I63449, I6349, I6350, I63511, I63512, I63513, I63519, I63521, I63522, I63523, I63529, I63531, I63532, I63533, I63539, I63541, I63542, I63543, I63549, I6359, I636, I638, I6381, I6389, I639, I6501, I6502, I6503, I6509, I651, I6521, I6522, I6523, I6529, I658, I659, I6601, I6602, I6603, I6609, I6611, I6612, I6613, I6619, I6621, I6622, I6623, I6629, I663, I668, I669, I6930, I6931, I69310, I69311, I69312, I69313, I69314, I69315, I69318, I69319, I69320, I69321, I69322, I69323, I69328, I69390, I69391, I69392, I69393, I69398, I6980, I6981, I69810, I69811, I69812, I69813, I69814, I69815, I69818, I69819, I69820, I69821, I69822, I69823, I69828, I69890, I69891, I69892, I69893, I69898, I6990, I6991, I69910, I69911, I69912, I69913, I69914, I69915, I69918, I69919, I69920, I69921, I69922, I69923, I69928, I69990, I69991, I69992, I69993, I69998, P91821, P91822, P91823, P91829, I69331, I69332, I69333, I69334, I69339, I69341, I69342, I69343, I69344, I69349, I69351, I69352, I69353, I69354, I69359, I69361, I69362, I69363, I69364, I69365, I69369, I69831, I69832, I69833, I69834, I69839, I69841, I69842, I69843, I69844, I69849, I69851, I69852, I69853, I69854, I69859, I69861, I69862, I69863, I69864, I69865, I69869, I69931, I69932, I69933, I69934, I69939, I69941, I69942, I69943, I69944, I69949, I69951, I69952, I69953, I69954, I69959, I69961, I69962, I69963, I69964, I69965, I69969

Malignant solid tumor	C000, C001, C002, C003, C004, C005, C006, C008, C009, C01, C020, C021, C022, C023, C024, C028, C029, C030, C031, C039, C040, C041, C048, C049, C050, C051, C052, C058, C059, C060, C061, C062, C0680, C0689, C069, C07, C080, C081, C089, C090, C091, C098, C099, C100, C101, C102, C103, C104, C108, C109, C110, C111, C112, C113, C118, C119, C12", C130, C131, C132, C138, C139, C140, C142, C148, C153, C154, C155, C158, C159, C160, C161, C162, C163, C164, C165, C166, C168, C169, C170, C171, C172, C173, C178, C179, C180, C181, C182, C183, C184, C185, C186, C187, C188, C189, C19, C20, C210, C211, C212, C218, C220, C221, C222, C223, C224, C227, C228, C229, C23, C240, C241, C248, C249, C250, C251, C252, C253, C254, C257, C258, C259, C260, C261, C269, C300, C301, C310, C311, C312, C313, C318, C319, C320, C321, C322, C323, C328, C329, C33, C3400, C3401, C3402, C3410, C3411, C3412, C342, C3430, C3431, C3432, C3480, C3481, C3482, C3490, C3491, C3492, C37, C380, C381, C382, C383, C384, C388, C390, C399, C4000, C4001, C4002, C4010, C4011, C4012, C4020, C4021, C4022, C4030, C4031, C4032, C4080, C4081, C4082, C4090, C4091, C4092, C410, C411, C412, C413, C414, C419, C430, C4310, C4311, C43111, C43112, C4312, C43121, C43122, C4320, C4321, C4322, C4330, C4331, C4339, C434, C4351, C4352, C4359, C4360, C4361, C4362, C4370, C4371, C4372, C438, C439, C4400, C4409, C44101, C44102, C44102, C44102, C44109, C44109, C44109, C44131, C44132, C44132, C44139, C44139, C44191, C44192, C44192, C44192, C44199, C44199, C44199, C44201, C44202, C44209, C44291, C44292, C44299, C44300, C44301, C44309, C44390, C44391, C44399, C4440, C4449, C44500, C44501, C44509, C44590, C44591, C44599, C44601, C44602, C44609, C44691, C44692, C44699, C44701, C44702, C44709, C44791, C44792, C44799, C4480, C4489, C4490, C4499, C450, C451, C452, C457, C459, C460, C461, C462, C463, C464, C4650, C4651, C4652, C467, C469, C470, C4710, C4711, C4712, C4720, C4721, C4722, C473, C474, C475, C476, C478, C479, C480, C481, C482, C488, C490, C4910, C4911, C4912, C4920, C4921, C4922, C493, C494, C495, C496, C498, C499, C49A0, C49A1, C49A2, C49A3, C49A4, C49A5, C49A9, C4A0, C4A10, C4A11, C4A111, C4A112, C4A12, C4A121, C4A122, C4A20, C4A21, C4A22, C4A30, C4A31, C4A39, C4A4, C4A51, C4A52, C4A59, C4A60, C4A61, C4A62, C4A70, C4A71, C4A72, C4A8, C4A9, C50011, C50012, C50019, C50021, C50022, C50029, C50111, C50112, C50119, C50121, C50122, C50129, C50211, C50212, C50219, C50221, C50222, C50229, C50311, C50312, C50319, C50321, C50322, C50329, C50411, C50412,

	C50419, C50421, C50422, C50429, C50511, C50512, C50519, C50521, C50522, C50529, C50611, C50612, C50619, C50621, C50622, C50629, C50811, C50812, C50819, C50821, C50822, C50829, C50911, C50912, C50919, C50921, C50922, C50929, C510, C511, C512, C518, C519, C52, C530, C531, C538, C539, C540, C541, C542, C543, C548, C549, C55, C561, C562, C563, C569, C5700, C5701, C5702, C5710, C5711, C5712, C5720, C5721, C5722, C573, C574, C577, C578, C579, C58, C600, C601, C602, C608, C609, C61, C6200, C6201, C6202, C6210, C6211, C6212, C6290, C6291, C6292, C6300, C6301, C6302, C6310, C6311, C6312, C632, C637, C638, C639, C641, C642, C649, C651, C652, C659, C661, C662, C669, C670, C671, C672, C673, C674, C675, C676, C677, C678, C679, C680, C681, C688, C689, C6900, C6901, C6902, C6910, C6911, C6912, C6920, C6921, C6922, C6930, C6931, C6932, C6940, C6941, C6942, C6950, C6951, C6952, C6960, C6961, C6962, C6980, C6981, C6982, C6990, C6991, C6992, C700, C701, C709, C710, C711, C712, C713, C714, C715, C716, C717, C718, C719, C720, C721, C7220, C7221, C7222, C7230, C7231, C7232, C7240, C7241, C7242, C7250, C7259, C729, C73, C7400, C7401, C7402, C7410, C7411, C7412, C7490, C7491, C7492, C750, C751, C752, C753, C754, C755, C758, C759, C760, C761, C762, C763, C7640, C7641, C7642, C7650, C7651, C7652, C768, C7A00, C7A010, C7A011, C7A012, C7A019, C7A020, C7A021, C7A022, C7A023, C7A024, C7A025, C7A026, C7A029, C7A090, C7A091, C7A092, C7A093, C7A094, C7A095, C7A096, C7A098, C7A1, C7A8, D469, E3121, E3122, E3123
Solid tumor in situ	D0000, D0001, D0002, D0003, D0004, D0005, D0006, D0007, D0008, D001, D002, D010, D011, D012, D013, D0140, D0149, D015, D017, D019, D020, D021, D0220, D0221, D0222, D023, D024, D030, D0310, D0311, D0311, D0311, D0312, D0312, D0312, D0320, D0321, D0322, D0330, D0339, D03, D0351, D0352, D0359, D0360, D0361, D0362, D0370, D0371, D0372, D038, D039, D040, D0410, D0411, D0411, D0411, D0412, D0412, D0412, D0420, D0421, D0422, D0430, D0439, D044, D045, D0460, D0461, D0462, D0470, D0471, D0472, D048, D049, D0500, D0501, D0502, D0510, D0511, D0512, D0580, D0581, D0582, D0590, D0591, D0592, D060, D061, D067, D069, D070, D071, D072, D0730, D0739, D074, D075, D0760, D0761, D0769, D090, D0910, D0919, D0920, D0921, D0922, D093, D098, D099
Metastatic cancer	C770, C771, C772, C773, C774, C775, C778, C779, C7800, C7801, C7802, C781, C782, C7830, C7839, C784, C785, C786, C787, C7880, C7889, C7900, C7901, C7902, C7910, C7911, C7919, C792, C7931, C7932, C7940, C7949, C7951, C7952,

	C7960, C7961, C7962, C7963, C7970, C7971, C7972, C7981, C7982, C7989, C799, C7B00, C7B01, C7B02, C7B03, C7B04, C7B09, C7B1, C7B8, C800
Lymphoma	C8100, C8101, C8102, C8103, C8104, C8105, C8106, C8107, C8108, C8109, C8110, C8111, C8112, C8113, C8114, C8115, C8116, C8117, C8118, C8119, C8120, C8121, C8122, C8123, C8124, C8125, C8126, C8127, C8128, C8129, C8130, C8131, C8132, C8133, C8134, C8135, C8136, C8137, C8138, C8139, C8140, C8141, C8142, C8143, C8144, C8145, C8146, C8147, C8148, C8149, C8170, C8171, C8172, C8173, C8174, C8175, C8176, C8177, C8178, C8179, C8190, C8191, C8192, C8193, C8194, C8195, C8196, C8197, C8198, C8199, C8200, C8201, C8202, C8203, C8204, C8205, C8206, C8207, C8208, C8209, C8210, C8211, C8212, C8213, C8214, C8215, C8216, C8217, C8218, C8219, C8220, C8221, C8222, C8223, C8224, C8225, C8226, C8227, C8228, C8229, C8230, C8231, C8232, C8233, C8234, C8235, C8236, C8237, C8238, C8239, C8240, C8241, C8242, C8243, C8244, C8245, C8246, C8247, C8248, C8249, C8250, C8251, C8252, C8253, C8254, C8255, C8256, C8257, C8258, C8259, C8260, C8261, C8262, C8263, C8264, C8265, C8266, C8267, C8268, C8269, C8280, C8281, C8282, C8283, C8284, C8285, C8286, C8287, C8288, C8289, C8290, C8291, C8292, C8293, C8294, C8295, C8296, C8297, C8298, C8299, C8300, C8301, C8302, C8303, C8304, C8305, C8306, C8307, C8308, C8309, C8310, C8311, C8312, C8313, C8314, C8315, C8316, C8317, C8318, C8319, C8330, C8331, C8332, C8333, C8334, C8335, C8336, C8337, C8338, C8339, C8350, C8351, C8352, C8353, C8354, C8355, C8356, C8357, C8358, C8359, C8370, C8371, C8372, C8373, C8374, C8375, C8376, C8377, C8378, C8379, C8380, C8381, C8382, C8383, C8384, C8385, C8386, C8387, C8388, C8389, C8390, C8391, C8392, C8393, C8394, C8395, C8396, C8397, C8398, C8399, C8400, C8401, C8402, C8403, C8404, C8405, C8406, C8407, C8408, C8409, C8410, C8411, C8412, C8413, C8414, C8415, C8416, C8417, C8418, C8419, C8440, C8441, C8442, C8443, C8444, C8445, C8446, C8447, C8448, C8449, C8460, C8461, C8462, C8463, C8464, C8465, C8466, C8467, C8468, C8469, C8470, C8471, C8472, C8473, C8474, C8475, C8476, C8477, C8478, C8479, C847A, C8490, C8491, C8492, C8493, C8494, C8495, C8496, C8497, C8498, C8499, C84A0, C84A1, C84A2, C84A3, C84A4, C84A5, C84A6, C84A7, C84A8, C84A9, C84Z0, C84Z1, C84Z2, C84Z3, C84Z4, C84Z5, C84Z6, C84Z7, C84Z8, C84Z9, C8510, C8511, C8512, C8513, C8514, C8515, C8516, C8517, C8518, C8519, C8520, C8521, C8522, C8523, C8524, C8525, C8526, C8527, C8528, C8529, C8580, C8581, C8582, C8583, C8584, C8585, C8586, C8587, C8588, C8589, C8590,

	C8591, C8592, C8593, C8594, C8595, C8596, C8597, C8598, C8599, C860, C861, C862, C863, C864, C865, C866, C880, C882, C883, C884, C888, C889, C9000, C9001, C9002, C9020, C9021, C9022, C9030, C9031, C9032, C960, C962, C9620, C9621, C9622, C9629, C964, C969, C96A, C96Z, D47Z9
Leukemia	C9010, C9011, C9012, C9100, C9101, C9102, C9110, C9111, C9112, C9130, C9131, C9132, C9140, C9141, C9142, C9150, C9151, C9152, C9160, C9161, C9162, C9190, C9191, C9192, C91A0, C91A1, C91A2, C91Z0, C91Z1, C91Z2, C9200, C9201, C9202, C9210, C9211, C9212, C9220, C9221, C9222, C9230, C9231, C9232, C9240, C9241, C9242, C9250, C9251, C9252, C9260, C9261, C9262, C9290, C9291, C9292, C92A0, C92A1, C92A2, C92Z0, C92Z1, C92Z2, C9300, C9301, C9302, C9310, C9311, C9312, C9330, C9331, C9332, C9390, C9391, C9392, C93Z0, C93Z1, C93Z2, C9400, C9401, C9402, C9420, C9421, C9422, C9430, C9431, C9432, C9440, C9441, C9442, C946, C9480, C9481, C9482, C9500, C9501, C9502, C9510, C9511, C9512, C9590, C9591, C9592
Chronic Pulmonary disease	J410, J411, J418, J42, J430, J431, J432, J438, J439, J440, J441, J449, J4520, J4521, J4522, J4530, J4531, J4532, J4540, J4541, J4542, J4550, J4551, J4552, J45901, J45902, J45909, J45990, J45991, J45998, J470, J471, J479, J60, J61, J620, J628, J630, J631, J632, J633, J634, J635, J636, J64, J65, J660, J661, J662, J668, J670, J671, J672, J673, J674, J675, J676, J677, J678, J679, J684, J701, J703
Moderate renal failure & disease	N183, N1830, N1831, N1832, N189, N19
Severe renal failure & disease	N184, N185, N186, Z4901, Z4902, Z4931, Z4932, Z9115, Z940, Z992
Obesity	E6601, E6609, E661, E662, E668, E669, O99210, O99211, O99212, O99213, O99214, O99215, R939, Z6830, Z6831, Z6832, Z6833, Z6834, Z6835, Z6836, Z6837, Z6838, Z6839, Z6841, Z6842, Z6843, Z6844, Z6845, Z6854
Drug abuse	F1110, F1111, F11120, F11121, F11122, F11129, F1113, F1114, F11181, F11182, F11188, F1119, F1120, F1121, F11220, F11221, F11222, F11229, F1123, F1124, F11281, F11282, F11288, F1129, F1210, F1211, F12120, F12121, F12122, F12129, F1213, F12180, F12188, F1219, F1220, F1221, F12220, F12221, F12222, F12229, F1223, F12280, F12288, F1229, F1310, F1311, F13120, F13121, F13129, F13130, F13131, F13132, F13139, F1314, F13180, F13181, F13182, F13188, F1319, F1320, F1321, F13220, F13221, F13229, F13230, F13231, F13232, F13239, F1324, F1326, F1327, F13280, F13281, F13282, F13288, F1329, F1410, F1411, F14120, F14121, F14122, F14129, F1413, F1414, F14180, F14181, F14182, F14188, F1419, F1420, F1421,

	F14220, F14221, F14222, F14229, F1423, F1424, F14280, F14281, F14282, F14288, F1429, F1510, F1511, F15120, F15121, F15122, F15129, F1513, F1514, F15180, F15181, F15182, F15188, F1519, F1520, F1521, F15220, F15221, F15222, F15229, F1523, F1524, F15280, F15281, F15282, F15288, F1529, F1610, F1611, F16120, F16121, F16122, F16129, F1614, F16180, F16183, F16188, F1619, F1620, F1621, F16220, F16221, F16229, F1624, F16280, F16283, F16288, F1629, F1810, F1811, F18120, F18121, F18129, F1814, F1817, F18180, F18188, F1819, F1820, F1821, F18220, F18221, F18229, F1824, F1827, F18280, F18288, F1829, F1910, F1911, F19120, F19121, F19122, F19129, F19130, F19131, F19132, F19139, F1914, F1916, F1917, F19180, F19181, F19182, F19188, F1919, F1920, F1921, F19220, F19221, F19222, F19229, F19230, F19231, F19232, F19239, F1924, F1926, F1927, F19280, F19281, F19282, F19288, F1929, O99320, O99321, O99322, O99323, O99324, O99325, F11150, F11151, F11159, F11250, F11251, F11259, F12150, F12151, F12159, F12250, F12251, F12259, F13150, F13151, F13159, F13250, F13251, F13259, F14150, F14151, F14159, F14250, F14251, F14259, F15150, F15151, F15159, F15250, F15251, F15259, F16150, F16151, F16159, F16250, F16251, F16259, F18150, F18151, F18159, F18250, F18251, F18259, F19150, F19151, F19159, F19250, F19251, F19259
Alcohol abuse	F1010, F1011, F10120, F10121, F10129, F10130, F10131, F10132, F10139, F1014, F10150, F10151, F10159, F10180, F10181, F10182, F10188, F1019, F1020, F1021, F10220, F10221, F10229, F10230, F10231, F10232, F10239, F1024, F10250, F10251, F10259, F1026, F1027, F10280, F10281, F10282, F10288, F1029, F1094, F10950, F10951, F10959, F1096, F1097, F10980, G621, I426, K2920, K2921, O99310, O99311, O99312, O99313, O99314, O99315, K7010, K7011

Appendix 5: Elixhauser comorbidity indices for readmission and in-hospital mortality used in the analyses

Comorbidity measures	Risk of in-hospital mortality index weight [a, b]	Risk of 30-day, all-cause readmission index weight [a, b]
Acquired Immune Deficiency Syndrome (AIDS)	-4	5
Alcohol abuse	-1	3
Deficiency anemias	-3	5
Autoimmune conditions	-1	2
Chronic blood loss	-4	2
Leukemia	9	10
Lymphoma	6	7
Metastatic cancer	23	11
Solid tumor without metastasis, in situ	0	0
Solid tumor without metastasis, malignant	10	7
Cerebrovascular disease	5	0
Coagulopathy	15	3
Dementia	5	1
Depression	-9	2
Diabetes with chronic complications	-2	4
Diabetes without chronic complications	0	0
Drug abuse	-7	6
Heart failure	15	7
Hypertension, complicated	1	0
Hypertension, uncomplicated	0	0
Liver disease, mild	2	3
Liver disease and failure, moderate to severe	17	10
Chronic pulmonary disease	2	4
Neurological disorders affecting movement	-1	1
Other neurological disorders	23	2
Seizures and epilepsy	2	5
Obesity	-7	-2
Paralysis	4	3
Peripheral vascular disease	3	1
Psychoses	-9	6
Pulmonary circulation disease	4	3
Renal (kidney) failure and disease, moderate	3	4

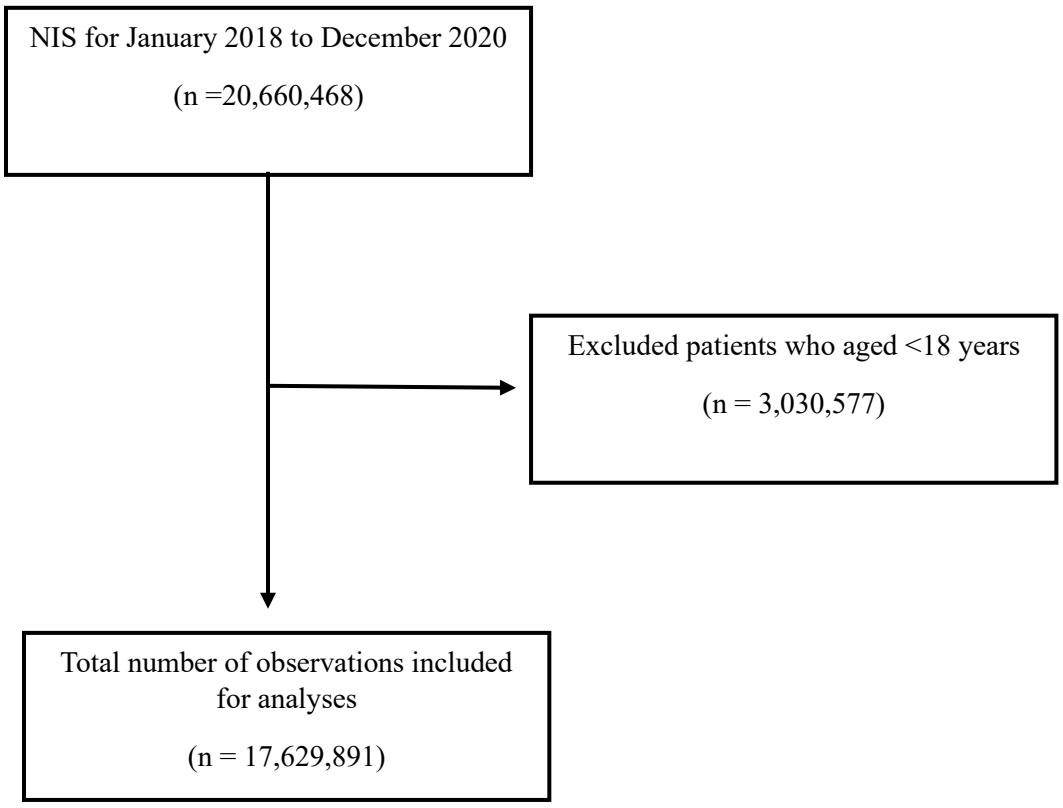
Renal (kidney) failure and disease, severe	8	8
Hypothyroidism	-3	0
Other thyroid disorders	-8	0
Peptic ulcer with bleeding	0	2
Valvular disease	0	0
Weight loss	14	6

[a] Greater comorbidity weight means increased predicted rates of both mortality and readmission.
[b] The risk of in-hospital mortality and 30-day, all-cause readmission index weights were updated in v2023.1
Source: Elixhauser comorbidity software refined for ICD-10-CM diagnoses, v2023.1

Appendix 6: ICD-10 codes for other comorbid conditions

Condition	ICD-10-CM Codes
Smoking history	F172, F1720, F17200, F17201, F17203, F17208, F17209, F1721, F17210, F17211, F17213, F17218, F17219, Z716, Z720, O9933, O99330, O99331, O99332, O99333, O99334, O99335, Z87891

Appendix 7: Study sample inclusion criteria and selection process for hospitalized patients ≥18 years



Appendix 8: Sample characteristics by year

N=17,629,891	ACSCs Hospitalizations n = 663,642	Non-ACSCs Hospitalizations n = 5,388,604	ACSCs Hospitalizations n = 665,755	Non-ACSCs Hospitalizations n = 5,378,157	ACSCs Hospitalizations n = 539,212	Non-ACSCs Hospitalizations n = 4,994,521
Year	**2018**		**2019**		**2020**	
Patient-level characteristics, n (%)						
Age, mean ± SD	66.4 ± 16.9	57.2 ± 20.4	66.4 ± 16.8	57.4 ± 20.3	65.7 ± 16.9	57.1 ± 20.3
Sex						
Male	311,050 (46.9%)	2,269,187 (42.1%)	315,732 (47.4%)	2,280,099 (42.4%)	266,590 (49.4%)	2,159,074 (43.2%)
Female	352,564 (53.1%)	3,118,892 (57.9%)	349,995 (52.6%)	3,097,388 (57.6%)	272,610 (50.6%)	2,834,848 (56.8%)
Race						
White	424,527 (65.2%)	3,525,043 (67.2%)	427,267 (65.3%)	3,543,094 (67.5%)	339,538 (64.2%)	3,201,900 (65.8%)
Black	128,772 (19.8%)	762,002 (14.5%)	132,222 (20.2%)	771,654 (14.7%)	112,180 (21.2%)	742,181 (15.3%)
Hispanic	65,578 (10.1%)	613,430 (11.7%)	62,448 (9.6%)	590,118 (11.2%)	51,227 (9.7%)	589,981 (12.1%)
Asian or Pacific Islander	12,598 (1.9%)	151,879 (2.9%)	12,742 (2.0%)	152,516 (2.9%)	9,844 (1.9%)	142,973 (2.9%)
Native American	3,842 (0.6%)	34,475 (0.7%)	3,996 (0.6%)	36,236 (0.7%)	3,310 (0.6%)	35,827 (0.7%)
Other	15,640 (2.4%)	163,046 (3.1%)	15,255 (2.3%)	156,438 (3.0%)	12,492 (2.4%)	152,603 (3.1%)
Median household income quartile for patient's ZIP Code						
Poorest	226,599 (34.8%)	1,537,382 (29.1%)	233,377 (35.7%)	1,583,612 (30.0%)	190,188 (35.9%)	1,475,010 (30.1%)
Second poorest	180,539 (27.7%)	1,426,940 (27.0%)	171,247 (26.2%)	1,339,038 (25.4%)	147,728 (27.9%)	1,333,101 (27.2%)
Second richest	142,747 (21.9%)	1,270,300 (24.0%)	145,770 (22.3%)	1,295,705 (24.5%)	110,148 (20.8%)	1,128,728 (23.0%)
Richest	102,075 (15.7%)	1,057,713 (20.0%)	103,469 (15.8%)	1,063,356 (20.1%)	81,084 (15.3%)	966,917 (19.7%)
Hospital region						
Northeast	124,480 (18.8%)	999,535 (18.6%)	121,511 (18.3%)	992,170 (18.5%)	95,635 (17.7%)	911,405 (18.3%)

Midwest	145,915 (22.0%)	1,207,350 (22.4%)	145,790 (21.9%)	1,197,021 (22.3%)	115,740 (21.5%)	1,096,737 (22.0%)
South	286,475 (43.2%)	2,106,260 (39.1%)	288,761 (43.4%)	2,119,407 (39.4%)	237,796 (44.1%)	1,995,644 (40.0%)
West	106,772 (16.1%)	1,075,459 (20.0%)	109,693 (16.5%)	1,069,559 (19.9%)	90,041 (16.7%)	990,735 (19.8%)
Lifestyle factors, n (%)						
Smoking history	307,830 (46.4%)	1,894,008 (35.2%)	309,528 (46.5%)	1,896,549 (35.3%)	247,098 (45.8%)	1,730,642 (34.7%)
Obesity	143,282 (21.6%)	905,832 (16.8%)	148,850 (22.4%)	921,576 (17.1%)	130,525 (24.2%)	929,823 (18.6%)
Drug abuse	30,613 (4.6%)	297,907 (5.5%)	32,183 (4.8%)	296,977 (5.5%)	29,585 (5.5%)	288,278 (5.8%)
Alcohol abuse	24,155 (3.6%)	301,843 (5.6%)	24,616 (3.7%)	303,853 (5.7%)	22,804 (4.2%)	303,251 (6.1%)
Comorbidities, n (%)						
Hypertension, complicated	157,758 (23.8%)	1,127,682 (20.9%)	161,415 (24.3%)	1,177,440 (21.9%)	132,021 (24.5%)	1,125,715 (22.5%)
Hypertension, uncomplicated	181,547 (27.4%)	1,750,211 (32.5%)	176,579 (26.5%)	1,731,967 (32.2%)	141,119 (26.2%)	1,580,892 (31.7%)
Diabetes with chronic complications	229,138 (34.5%)	777,969 (14.4%)	239,564 (36.0%)	813,106 (15.1%)	208,483 (38.7%)	813,666 (16.3%)
Diabetes without chronic complications	69,662 (10.5%)	574,803 (10.7%)	65,087 (9.8%)	551,684 (10.3%)	48,156 (8.9%)	505,415 (10.1%)
Metastatic cancer	9,662 (1.5%)	175,108 (3.3%)	10,012 (1.5%)	182,009 (3.4%)	8,269 (1.5%)	168,998 (3.4%)
Cerebrovascular disease	28,312 (4.3%)	240,188 (4.5%)	29,519 (4.4%)	247,590 (4.6%)	24,777 (4.6%)	236,642 (4.7%)
Liver disease, mild	32,273 (4.9%)	268,162 (5.0%)	33,609 (5.1%)	275,534 (5.1%)	30,549 (5.7%)	273,288 (5.5%)
Liver disease, severe	4,776 (0.7%)	91,946 (1.7%)	5,127 (0.8%)	96,164 (1.8%)	4,827 (0.9%)	96,775 (1.9%)
Renal failure, moderate	134,364 (20.3%)	500,073 (9.3%)	140,894 (21.2%)	528,242 (9.8%)	117,295 (21.8%)	505,214 (10.1%)
Renal failure, severe	73,365 (11.1%)	289,614 (5.4%)	77,144 (11.6%)	296,330 (5.5%)	66,782 (12.4%)	284,133 (5.7%)
Elixhauser comorbidity score, median (IQR)						
Mortality score	7 (17)	0 (15)	7 (17)	0 (15)	8 (17)	0 (16)
Readmission score	11 (13)	5 (12)	11 (13)	5 (12)	11 (13)	6 (13)

Appendix 9: Baseline characteristics by race among patients hospitalized with all ACSCs

n=1,868,609	White n= 1,191,332	Black n= 373,174	Hispanic n= 179,253	Asian or Pacific Islander n= 35,184	Native American n= 11,148	Other n= 43,387
Patient level characteristics, n (%)						
Age, mean ± SD	69.1 ± 15.9	59.3 ± 16.6	61.5 ± 18.0	68.4 ± 16.8	59.7 ± 16.7	64.3 ± 17.5
Sex						
Male	563,493 (47.3%)	178,400 (47.8%)	90,044 (50.2%)	17,578 (50.0%)	5,212 (46.8%)	21,643 (49.9%)
Female	627,802 (52.7%)	194,754 (52.2%)	89,202 (49.8%)	17,606 (50.0%)	5,935 (53.2%)	21,744 (50.1%)
Median household income for patient's zip code						
Poorest	338,238 (28.9%)	202,076 (55.2%)	73,497 (42.0%)	5,146 (14.8%)	5,310 (50.3%)	13,269 (31.4%)
Second poorest	341,875 (29.2%)	80,551 (22.0%)	45,471 (26.0%)	6,957 (20.1%)	2,745 (26.0%)	9,966 (23.6%)
Second richest	281,694 (24.0%)	52,965 (14.5%)	36,244 (20.7%)	9,622 (27.7%)	1,720 (16.3%)	9,916 (23.5%)
Richest	210,009 (17.9%)	30,620 (8.4%)	19,773 (11.3%)	12,956 (37.4%)	776 (7.4%)	9,047 (21.4%)
Hospital region						
Northeast	225,432 (18.9%)	60,680 (16.3%)	32,892 (18.4%)	6,242 (17.7%)	570 (5.1%)	13,423 (30.9%)
Midwest	293,832 (24.7%)	75,762 (20.3%)	11,863 (6.6%)	3,321 (9.4%)	2,189 (19.6%)	4,656 (10.7%)
South	496,253 (41.7%)	205,495 (55.1%)	73,270 (40.9%)	5,639 (16.1%)	3,867 (34.7%)	16,549 (38.1%)
West	175,815 (14.8%)	31,237 (8.4%)	61,228 (34.2%)	19,982 (56.8%)	4,522 (40.6%)	8,759 (20.2%)
Lifestyle factors						
Smoking history	582,510 (48.9%)	171,929 (46.1%)	61,473 (34.3%)	10,897 (31.0%)	5,299 (47.5%)	16,318 (37.6%)
Obesity	258,414 (21.7%)	101,912 (27.3%)	39,781 (22.2%)	4,276 (12.2%)	2,471 (22.2%)	8,474 (19.5%)
Drug abuse	47,079 (4.0%)	29,928 (8.0%)	9,934 (5.5%)	1,088 (3.1%)	952 (8.5%)	2,027 (4.7%)
Alcohol abuse	43,258 (3.6%)	16,844 (4.5%)	6,921 (3.9%)	656 (1.9%)	1,006 (9.0%)	1,543 (3.6%)
Comorbidities, n (%)						
Hypertension, complicated	271,039 (22.8%)	107,712 (28.9%)	43,118 (24.1%)	8,678 (24.7%)	2,653 (23.8%)	9,940 (22.9%)
Hypertension, uncomplicated	319,659 (26.8%)	97,329 (26.1%)	49,047 (27.4%)	8,804 (25.0%)	3,122 (28.0%)	11,784 (27.2%)
Diabetes with chronic complications	391,375 (32.9%)	155,758 (41.7%)	82,058 (45.8%)	14,649 (41.6%)	4,994 (44.8%)	16,578 (38.2%)
Diabetes without chronic complications	113,721 (9.6%)	36,025 (9.7%)	19,439 (10.8%)	4,084 (11.6%)	1,134 (10.2%)	1,134 (10.2%)
Metastatic cancer	20,052 (1.7%)	4,152 (1.1%)	1,847 (1.0%)	646 (1.8%)	108 (1.0%)	601 (1.4%)
Cerebrovascular disease	49,767 (4.2%)	4,152 (1.1%)	1,847 (1.0%)	646 (1.8%)	108 (1.0%)	601 (1.4%)
Liver disease, mild	55,549 (4.7%)	22,271 (6.0%)	11,787 (6.6%)	2,030 (5.8%)	873 (7.8%)	2,348 (5.4%)

Liver disease, severe	9,456 (0.8%)	2,125 (0.6%)	2,059 (1.2%)	305 (0.9%)	140 (1.3%)	385 (0.9%)
Renal failure, moderate	254,693 (21.4%)	81,894 (22.0%)	31,011 (17.3%)	7,683 (21.8%)	1,850 (16.6%)	8,037 (18.5%)
Renal failure, severe	103,480 (8.7%)	65,987 (17.7%)	29,973 (16.7%)	6,897 (19.6%)	1,634 (14.7%)	5,730 (13.2%)
Elixhauser comorbidity score, median (IQR)						
Mortality score	7 (17)	8 (17)	5 (18)	11 (19)	4 (17)	7 (17)
Readmission score	11 (12)	12 (14)	10 (14)	12 (15)	11 (13)	10 (14)

Appendix 10: Baseline characteristics by socioeconomic status among patients hospitalized with all ACSCs

n=1,868,609	Poorest n= 650,164	Second poorest n= 499,514	Second richest n= 398,665	Richest n= 286,628
Patient level characteristics, n (%)				
Age, mean ± SD	63.7 ± 16.7	66.3 ± 16.8	67.6 ± 16.8	70.2 ± 16.6
Sex				
Male	306,524 (47.2%)	238,193 (47.7%)	191,571 (48.1%)	137,586 (48.0%)
Female	343,607 (52.9%)	261,307 (52.3%)	207,080 (52.0%)	149,036 (52.0%)
Race				
White	338,238 (53.1%)	341,875 (70.1%)	281,694 (71.8%)	210,009 (74.2%)
Black	202,076 (31.7%)	80,551 (16.5%)	52,965 (13.5%)	30,620 (10.8%)
Hispanic	73,497 (11.5%)	45,471 (9.3%)	36,244 (9.2%)	19,773 (7.0%)
Asian or Pacific Islander	5,146 (0.8%)	6,957 (1.4%)	9,622 (2.5%)	12,956 (4.6%)
Native American	5,310 (0.8%)	2,745 (0.6%)	1,720 (0.4%)	776 (0.3%)
Other	13,269 (2.1%)	9,966 (2.0%)	9,916 (2.5%)	9,047 (3.2%)
Hospital region				
Northeast	78,635 (12.1%)	77,504 (15.5%)	86,916 (21.8%)	94,839 (33.1%)
Midwest	137,997 (21.2%)	126,661 (25.4%)	92,504 (23.2%)	47,498 (16.6%)
South	364,176 (56.0%)	218,902 (43.8%)	138,306 (34.7%)	77,681 (27.1%)
West	69,356 (10.7%)	76,447 (15.3%)	80,939 (20.3%)	66,610 (23.2%)
Lifestyle factors				
Smoking history	311,954 (48.0%)	233,936 (46.8%)	179,928 (45.1%)	121,229 (42.3%)
Obesity	154,196 (23.7%)	115,239 (23.1%)	90,840 (22.8%)	55,904 (19.5%)
Drug abuse	39,645 (6.1%)	22,240 (4.5%)	16,164 (4.1%)	9,215 (3.2%)
Alcohol abuse	26,560 (4.1%)	18,335 (3.7%)	14,331 (3.6%)	9,682 (3.4%)
Comorbidities, n (%)				
Hypertension, complicated	164,214 (25.3%)	120,327 (24.1%)	94,252 (23.6%)	65,191 (22.7%)
Hypertension, uncomplicated	179,604 (27.6%)	133,741 (26.8%)	103,728 (26.0%)	73,307 (25.6%)
Diabetes with chronic complications	245,589 (37.8%)	181,186 (36.3%)	143,741 (36.1%)	95,216 (33.2%)
Diabetes without chronic complications	68,741 (10.6%)	49,623 (9.9%)	36,308 (9.1%)	24,946 (8.7%)
Metastatic cancer	8,089 (1.2%)	7,417 (1.5%)	6,534 (1.6%)	5,481 (1.9%)
Cerebrovascular disease	28,321 (4.4%)	21,548 (4.3%)	17,903 (4.5%)	13,507 (4.7%)
Liver disease, mild	36,516 (5.6%)	24,499 (4.9%)	19,298 (4.8%)	13,153 (4.6%)
Liver disease, severe	4,995 (0.8%)	3,907 (0.8%)	3,269 (0.8%)	2,242 (0.8%)
Renal failure, moderate	129,308 (19.9%)	104,805 (21.0%)	87,256 (21.9%)	64,862 (22.6%)
Renal failure, severe	80,576 (12.4%)	55,879 (11.2%)	45,454 (11.4%)	32,209 (11.2%)

Elixhauser comorbidity score, median (IQR)				
Mortality score	7 (17)	7 (17)	8 (17)	9 (18)
Readmission score	11 (13)	11 (12)	11 (13)	11 (13)

Appendix 11: Baseline characteristics by hospital census region among patients hospitalized with all ACSCs

n=1,868,609	Northeast n= 341,626	Midwest n= 407,445	South n= 813,032	West n= 306,506
Patient level characteristics, n (%)				
Age, mean ± SD	68.0 ± 16.6	66.9 ± 16.8	65.3 ± 16.8	65.5 ± 17.4
Sex				
Male	163,321 (47.8%)	191,288 (47.0%)	382,756 (47.1%)	156,007 (50.9%)
Female	178,297 (52.2%)	216,143 (53.1%)	430,243 (52.9%)	150,486 (49.1%)
Race				
White	225,432 (66.5%)	293,832 (75.0%)	496,253 (62.0%)	175,815 (58.3%)
Black	60,680 (17.9%)	75,762 (19.4%)	205,495 (25.7%)	31,237 (10.4%)
Hispanic	32,892 (9.7%)	11,863 (3.0%)	73,270 (9.2%)	61,228 (20.3%)
Asian or Pacific Islander	6,242 (1.8%)	3,321 (0.9%)	5,639 (0.7%)	19,982 (6.6%)
Native American	570 (0.2%)	2,189 (0.6%)	3,867 (0.5%)	4,522 (1.5%)
Other	13,423 (4.0%)	4,656 (1.2%)	16,549 (2.1%)	8,759 (2.9%)
Median household income for patient's zip code				
Poorest	78,635 (23.3%)	137,997 (34.1%)	364,176 (45.6%)	69,356 (23.6%)
Second poorest	77,504 (22.9%)	126,661 (31.3%)	218,902 (27.4%)	76,447 (26.1%)
Second richest	86,916 (25.7%)	92,504 (22.9%)	138,306 (17.3%)	80,939 (27.6%)
Richest	94,839 (28.1%)	47,498 (11.7%)	77,681 (9.7%)	66,610 (22.7%)
Lifestyle factors				
Smoking history	153,054 (44.8%)	215,580 (52.9%)	361,126 (44.4%)	134,696 (44.0%)
Obesity	71,807 (21.0%)	105,076 (25.8%)	182,824 (22.5%)	62,950 (20.5%)
Drug abuse	14,451 (4.2%)	15,664 (3.8%)	36,183 (4.5%)	26,083 (8.5%)
Alcohol abuse	13,616 (4.0%)	15,466 (3.8%)	27,855 (3.4%)	14,638 (4.8%)
Comorbidities, n (%)				
Hypertension, complicated	79,260 (23.2%)	102,062 (25.1%)	200,964 (24.7%)	68,908 (22.5%)
Hypertension, uncomplicated	89,805 (26.3%)	105,170 (25.8%)	229,544 (28.2%)	74,726 (24.4%)
Diabetes with chronic complications	118,274 (34.6%)	149,596 (36.7%)	296,095 (36.4%)	113,220 (36.9%)
Diabetes without chronic complications	35,665 (10.4%)	37,622 (9.2%)	82,470 (10.1%)	27,148 (8.9%)
Metastatic cancer	5,720 (1.7%)	6,582 (1.6%)	11,244 (1.4%)	4,397 (1.4%)
Cerebrovascular disease	14,891 (4.4%)	18,437 (4.5%)	36,076 (4.4%)	13,204 (4.3%)
Liver disease, mild	16,422 (4.8%)	18,923 (4.6%)	40,828 (5.0%)	20,258 (6.6%)
Liver disease, severe	2,513 (0.7%)	3,075 (0.8%)	6,081 (0.8%)	3,061 (1.0%)
Renal failure, moderate	71,045 (20.8%)	95,192 (23.4%)	162,036 (19.9%)	64,280 (21.0%)
Renal failure, severe	39,555 (11.6%)	45,699 (11.2%)	94,619 (11.6%)	37,418 (12.2%)

Elixhauser comorbidity score, median (IQR)				
Mortality score	8 (17)	7 (17)	7 (17)	7 (17)
Readmission score	11 (12)	11 (13)	11 (12)	11 (13)

Appendix 12: All logistic regression analyses results for the PAH as outcome

N=17,629,891	Unadjusted Odds ratios [95% confidence intervals] and *P* values	Adjusted Odds ratios [95% confidence intervals] and *P* values
Age	1.03 [1.03-1.03] *P*<0.001	1.02 [1.02-1.02] *P*<0.001
Sex		
Female	*Reference Category*	
Male	1.14 [1.14-1.15] *P*<0.001	1.03 [1.03-1.04] *P*<0.001
Race		
White	*Reference Category*	
Black	1.66 [1.66-1.67] *P*<0.001	1.65 [1.64-1.66] *P*<0.001
Hispanic	1.11 [1.10-1.12] *P*<0.001	1.19 [1.18-1.19] *P*<0.001
Asian or Pacific Islander	0.88 [0.87-0.89] *P*<0.001	0.98 [0.97-0.99] *P*<0.05
Native American	1.15 [1.12-1.17] *P*<0.001	1.01 [0.99-1.03] *P*=0.41
Other	0.95 [0.94-0.96] *P*<0.001	1.02 [1.01-1.03] *P*<0.05
Median household income quartile for patient's ZIP Code		
Richest	*Reference Category*	
Second richest	1.16 [1.16-1.17] *P*<0.001	1.08 [1.08-1.09] *P*<0.001
Second poorest	1.29 [1.28-1.29] *P*<0.001	1.13 [1.12-1.13] *P*<0.001
Poorest	1.43 [1.43-1.44] *P*<0.001	1.21 [1.20-1.22] *P*<0.001
Region of hospital		
Northeast	*Reference Category*	
Midwest	1.04 [1.01-1.08] *P*<0.05	0.88 [0.85-0.91] *P*<0.001
South	1.09 [1.05-1.13] *P*<0.001	1.04 [1.01-1.07] *P*<0.05
West	0.89 [0.86-0.93] *P*<0.001	0.87 [0.84-0.91] *P*<0.001
Year		
2018	*Reference Category*	
2019	1.00 [1.00-1.01] *P*=0.11	0.99 [0.98-0.99] *P*<0.001
2020	0.86 [0.85-0.86] *P*<0.001	0.84 [0.83-0.84] *P*<0.001
Covariates		
Bed size of hospital	_	0.84 [0.84-0.84] *P*<0.001
Location/ teaching status of hospital	_	0.74 [0.74-0.75] *P*<0.001
Expected primary payer	_	0.97 [0.97-0.97] *P*<0.001
Lifestyle factors		
Smoking history	_	1.59 [1.58-1.59] *P*<0.001
Obesity	_	1.00 [1.00- 1.01] P=0.11
Drug abuse	_	1.04 [1.03-1.05] *P*<0.001
Alcohol abuse	_	0.79 [0.78-0.80] *P*<0.001
Comorbidities		
Moderate renal failure & disease	_	2.08 [2.07-2.10] *P*<0.001
Severe renal failure & disease	_	2.00 [1.99-2.02] *P*<0.001
Chronic Pulmonary disease	_	1.24 [1.23-1.24] *P*<0.001
Hypertension, uncomplicated	_	0.81 [0.80-0.81] *P*<0.001
Hypertension, complicated	_	0.16 [0.15-0.16] *P*<0.001
Heart failure	_	7.61 [7.57-7.66] *P*<0.001
Diabetes with chronic complications	_	2.49 [2.48-2.50] *P*<0.001

Diabetes without chronic complications	_	1.12 [1.11-1.12] *P*<0.001
Cerebrovascular disease	_	0.82 [0.81-0.83] *P*<0.001
Malignant solid tumor	_	0.95 [0.94-0.96] *P*<0.001
Solid tumor in situ	_	0.73 [0.66-0.82] *P*<0.001
Metastatic cancer	_	0.72 [0.71-0.73] *P*<0.001
Lymphoma	_	0.81 [0.80-0.83] *P*<0.001
Leukemia	_	0.95 [0.93-0.97] *P*<0.001
Elixhauser comorbidity score		
Mortality score	_	0.99 [0.99-0.99] *P*<0.001
Readmission score	_	0.99 [0.99-0.99] *P*<0.001
NIS hospital number; var (_cons)	0.15 [0.14-0.15]	0.11 [0.11-0.12]

Appendix 13: Baseline characteristics by race among patients hospitalized with chronic ACSCs (diabetes related complications, hypertension, heart failure, COPD, and adult asthma)

n=1,428,223	White n= 867,862	Black n= 323,208	Hispanic n= 142,333	Asian or Pacific Islander n= 27,309	Native American n= 8,632	Other n= 33,320
Patient level characteristics, n (%)						
Age, mean ± SD	68.0 ± 15.9	58.7 ± 16.3	60.7 ± 17.4	67.8 ± 16.6	58.8 ± 16.3	63.4 ± 17.2
Sex						
Male	439,777 (50.7%)	159,262 (49.3%)	76,521 (53.8%)	14,538 (53.2%)	4,366 (50.6%)	17,799 (53.4%)
Female	428,060 (49.3%)	163,930 (50.7%)	65,806 (46.2%)	12,771 (46.8%)	4,265 (49.4%)	15,521 (46.6%)
Median household income for patient's zip code						
Poorest	246,294 (28.9%)	175,388 (55.3%)	58,816 (42.4%)	4,077 (15.2%)	4,066 (49.7%)	10,443 (32.2%)
Second poorest	249,633 (29.3%)	70,004 (22.1%)	35,935 (25.9%)	5,387 (20.0%)	2,139 (26.1%)	7,642 (23.6%)
Second richest	206,728 (24.2%)	45,638 (14.4%)	28,699 (20.7%)	7,510 (27.9%)	1,362 (16.6%)	7,615 (23.5%)
Richest	150,441 (17.6%)	26,062 (8.2%)	15,349 (11.1%)	9,934 (36.9%)	623 (7.6%)	6,690 (20.7%)
Hospital region						
Northeast	166,068 (19.1%)	53,176 (16.5%)	27,008 (19.0%)	4,747 (17.4%)	460 (5.3%)	10,437 (31.3%)
Midwest	214,131 (24.7%)	66,281 (20.5%)	9,378 (6.6%)	2,486 (9.1%)	1,726 (20.0%)	3,515 (10.6%)
South	356,013 (41.0%)	175,950 (54.4%)	56,416 (39.6%)	4,250 (15.6%)	3,002 (34.8%)	12,515 (37.6%)
West	131,650 (15.2%)	27,801 (8.6%)	49,531 (34.8%)	15,826 (58.0%)	3,444 (39.9%)	6,853 (20.6%)
Lifestyle factors						
Smoking history	446,884 (51.5%)	151,765 (47.0%)	51,317 (36.1%)	9,048 (33.1%)	4,271 (49.5%)	13,212 (39.7%)
Obesity	210,412 (24.2%)	91,724 (28.4%)	33,694 (23.7%)	3,786 (13.9%)	2,040 (23.6%)	7,097 (21.3%)
Drug abuse	37,698 (4.3%)	27,292 (8.4%)	8,632 (6.1%)	993 (3.6%)	779 (9.0%)	1,733 (5.2%)
Alcohol abuse	34,699 (4.0%)	14,834 (4.6%)	6,035 (4.2%)	572 (2.1%)	814 (9.4%)	1,315 (4.0%)
Comorbidities, n (%)						
Hypertension, complicated	171,955 (19.8%)	90,891 (28.1%)	34,156 (24.0%)	6,497 (23.8%)	2,013 (23.3%)	7,323 (22.0%)
Hypertension, uncomplicated	191,889 (22.1%)	76,917 (23.8%)	34,355 (24.1%)	5,406 (19.8%)	2,224 (25.8%)	7,765 (23.3%)
Diabetes with chronic complications	333,425 (38.4%)	143,768 (44.5%)	73,516 (51.7%)	12,911 (47.3%)	4,398 (51.0%)	14,557 (43.7%)
Diabetes without chronic complications	72,236 (8.3%)	28,006 (8.7%)	12,520 (8.8%)	2,584 (9.5%)	676 (7.8%)	3,250 (9.8%)
Metastatic cancer	10,383 (1.2%)	2,559 (0.8%)	915 (0.6%)	293 (1.1%)	55 (0.6%)	279 (0.8%)
Cerebrovascular disease	34,624 (4.0%)	15,962 (4.9%)	5,637 (4.0%)	1,552 (5.7%)	301 (3.5%)	1,502 (4.5%)
Liver disease, mild	43,642 (5.0%)	20,033 (6.2%)	9,799 (6.9%)	1,660 (6.1%)	679 (7.9%)	1,914 (5.7%)

Liver disease, severe	7,606 (0.9%)	1,924 (0.6%)	1,707 (1.2%)	257 (0.9%)	97 (1.1%)	314 (0.9%)
Renal failure, moderate	202,706 (23.4%)	73,478 (22.7%)	26,497 (18.6%)	6,531 (23.9%)	1,518 (17.6%)	6,693 (20.1%)
Renal failure, severe	95,096 (11.0%)	64,319 (19.9%)	29,084 (20.4%)	6,610 (24.2%)	1,549 (17.9%)	5,492 (16.5%)
Elixhauser comorbidity score, median (IQR)						
Mortality score	9 (17)	8 (17)	6 (17)	13 (18)	5 (17)	8 (17)
Readmission score	12 (12)	13 (14)	12 (14)	14 (14)	12 (13)	11 (14)

Appendix 14: Baseline characteristics by socioeconomic status among patients hospitalized with chronic ACSCs (diabetes related complications, hypertension, heart failure, COPD, and adult asthma)

n=1,428,223	Poorest n= 508,428	Second poorest n= 379,196	Second richest n= 302,354	Richest n= 211,598
Patient level characteristics, n (%)				
Age, mean ± SD	62.4 ± 16.4	65.0 ± 16.6	66.5 ± 16.7	69.3 ± 16.5
Sex				
Male	253,170 (49.8%)	192,264 (50.7%)	154,918 (51.2%)	108,916 (51.5%)
Female	255,234 (50.2%)	186,922 (49.3%)	147,424 (48.8%)	102,677 (48.5%)
Race				
White	246,294 (49.4%)	249,633 (67.3%)	206,728 (69.5%)	150,441 (72.0%)
Black	175,388 (35.1%)	70,004 (18.9%)	45,638 (15.3%)	26,062 (12.5%)
Hispanic	58,816 (11.8%)	35,935 (9.7%)	28,699 (9.7%)	15,349 (7.3%)
Asian or Pacific Islander	4,077 (0.8%)	5,387 (1.5%)	7,510 (2.5%)	9,934 (4.8%)
Native American	4,066 (0.8%)	2,139 (0.6%)	1,362 (0.5%)	623 (0.3%)
Other	10,443 (2.1%)	7,642 (2.1%)	7,615 (2.6%)	6,690 (3.2%)
Hospital region				
Northeast	64,686 (12.7%)	59,923 (15.8%)	66,708 (22.1%)	69,476 (32.8%)
Midwest	109,518 (21.5%)	93,500 (24.7%)	69,011 (22.8%)	34,866 (16.5%)
South	279,594 (55.0%)	166,375 (43.9%)	103,597 (34.3%)	56,464 (26.7%)
West	54,630 (10.7%)	59,398 (15.7%)	63,038 (20.9%)	50,792 (24.0%)
Lifestyle factors				
Smoking history	253,760 (49.9%)	185,125 (48.8%)	141,796 (46.9%)	93,871 (44.4%)
Obesity	130,998 (25.8%)	96,119 (25.4%)	75,760 (25.1%)	46,395 (21.9%)
Drug abuse	33,909 (6.7%)	18,606 (4.9%)	13,528 (4.5%)	7,687 (3.6%)
Alcohol abuse	22,206 (4.4%)	15,139 (4.0%)	11,820 (3.9%)	7,957 (3.8%)
Comorbidities, n (%)				
Hypertension, complicated	121,705 (23.9%)	83,443 (22.0%)	64,879 (21.5%)	42,879 (20.3%)
Hypertension, uncomplicated	123,210 (24.2%)	86,585 (22.8%)	65,476 (21.7%)	42,907 (20.3%)
Diabetes with chronic complications	216,513 (42.6%)	157,686 (41.6%)	125,490 (41.5%)	82,764 (39.1%)
Diabetes without chronic complications	46,958 (9.2%)	32,521 (8.6%)	23,755 (7.9%)	16,014 (7.6%)
Metastatic cancer	4,318 (0.9%)	3,909 (1.0%)	3,430 (1.1%)	2,879 (1.4%)
Cerebrovascular disease	21,097 (4.2%)	15,711 (4.1%)	13,133 (4.3%)	9,702 (4.6%)
Liver disease, mild	30,258 (6.0%)	19,938 (5.3%)	15,656 (5.2%)	10,633 (5.0%)
Liver disease, severe	4,062 (0.8%)	3,194 (0.8%)	2,746 (0.9%)	1,864 (0.9%)
Renal failure, moderate	107,997 (21.2%)	85,394 (22.5%)	71,662 (23.7%)	52,862 (25.0%)

Renal failure, severe	76,793 (15.1%)	52,595 (13.9%)	42,843 (14.2%)	30,246 (14.3%)
Elixhauser comorbidity score, median (IQR)				
Mortality score	8 (16)	8 (17)	9 (17)	11 (18)
Readmission score	12 (13)	12 (13)	12 (13)	12 (13)

Appendix 15: Baseline characteristics by hospital census region among patients hospitalized with chronic ACSCs (diabetes related complications, hypertension, heart failure, COPD, and adult asthma)

n=1,428,223	Northeast n= 263,695	Midwest n= 309,043	South n= 616,681	West n= 238,804
Patient level characteristics, n (%)				
Age, mean ± SD	67.1 ± 16.4	65.7 ± 16.7	63.9 ± 16.5	64.2 ± 17.2
Sex				
Male	132,765 (50.4%)	153,783 (49.8%)	309,284 (50.2%)	129,701 (54.3%)
Female	130,924 (49.7%)	155,248 (50.2%)	307,372 (49.8%)	109,095 (45.7%)
Race				
White	166,068 (63.4%)	214,131 (72.0%)	356,013 (58.5%)	131,650 (56.0%)
Black	53,176 (20.3%)	66,281 (22.3%)	175,950 (28.9%)	27,801 (11.8%)
Hispanic	27,008 (10.3%)	9,378 (3.2%)	56,416 (9.3%)	49,531 (21.1%)
Asian or Pacific Islander	4,747 (1.8%)	2,486 (0.8%)	4,250 (0.7%)	15,826 (6.7%)
Native American	460 (0.2%)	1,726 (0.6%)	3,002 (0.5%)	3,444 (1.5%)
Other	10,437 (4.0%)	3,515 (1.2%)	12,515 (2.1%)	6,853 (2.9%)
Median household income for patient's zip code				
Poorest	64,686 (24.8%)	109,518 (35.7%)	279,594 (46.1%)	54,630 (24.0%)
Second poorest	59,923 (23.0%)	93,500 (30.5%)	166,375 (27.5%)	59,398 (26.1%)
Second richest	66,708 (25.6%)	69,011 (22.5%)	103,597 (17.1%)	63,038 (27.7%)
Richest	69,476 (26.6%)	34,866 (11.4%)	56,464 (9.3%)	50,792 (22.3%)
Lifestyle factors				
Smoking history	122,535 (46.5%)	170,462 (55.2%)	286,536 (46.5%)	109,451 (45.8%)
Obesity	60,774 (23.1%)	87,536 (28.3%)	153,133 (24.8%)	53,341 (22.3%)
Drug abuse	12,028 (4.6%)	13,233 (4.3%)	30,186 (4.9%)	22,826 (9.6%)
Alcohol abuse	11,324 (4.3%)	12,776 (4.1%)	22,853 (3.7%)	12,408 (5.2%)
Comorbidities, n (%)				
Hypertension, complicated	56,652 (21.5%)	69,943 (22.6%)	141,894 (23.0%)	49,757 (20.8%)
Hypertension, uncomplicated	58,886 (22.3%)	67,476 (21.8%)	149,103 (24.2%)	48,971 (20.5%)
Diabetes with chronic complications	104,811 (39.8%)	129,798 (42.0%)	257,600 (41.8%)	100,447 (42.1%)
Diabetes without chronic complications	24,501 (9.3%)	24,725 (8.0%)	54,129 (8.8%)	18,160 (7.6%)
Metastatic cancer	3,129 (1.2%)	3,543 (1.2%)	5,697 (0.9%)	2,379 (1.0%)
Cerebrovascular disease	11,066 (4.2%)	13,714 (4.4%)	26,019 (4.2%)	9,854 (4.1%)
Liver disease, mild	13,432 (5.1%)	15,465 (5.0%)	33,045 (5.4%)	17,052 (7.1%)
Liver disease, severe	2,125 (0.8%)	2,566 (0.8%)	4,873 (0.8%)	2,558 (1.1%)
Renal failure, moderate	59,318 (22.5%)	77,562 (25.1%)	132,736 (21.5%)	53,683 (22.5%)

Renal failure, severe	37,470 (14.2%)	42,806 (13.9%)	89,508 (14.5%)	35,718 (15.0%)
Elixhauser comorbidity score, median (IQR)				
Mortality score	9 (17)	9 (17)	8 (17)	9 (17)
Readmission score	12 (13)	12 (13)	12 (13)	12 (13)

Appendix 16: Baseline characteristics by race among patients hospitalized with acute ACSCs (community acquired pneumonia and urinary tract infection)

n=440,399	White n= 323,479	Black n= 49,969	Hispanic n= 36,921	Asian or Pacific Islander n= 7,875	Native American n= 2,516	Other n= 10,067
Patient level characteristics, n (%)						
Age, mean ± SD	71.9 ± 15.8	63.3 ± 18.1	64.3 ± 19.5	70.7 ± 17.3	63.1 ± 17.7	67.4 ± 18.4
Sex						
Male	123,720 (38.3%)	19,139 (38.3%)	13,523 (36.6%)	3,040 (38.6%)	846 (33.6%)	3,844 (38.2%)
Female	199,747 (61.8%)	30,826 (61.7%)	23,397 (63.4%)	4,835 (61.4%)	1,670 (66.4%)	6,223 (61.8%)
Median household income for patient's zip code						
Poorest	91,947 (28.9%)	26,690 (54.3%)	14,681 (40.6%)	1,069 (13.8%)	1,244 (52.7%)	2,826 (28.8%)
Second poorest	92,245 (28.9%)	10,548 (21.5%)	9,536 (26.4%)	1,570 (20.2%)	606 (25.7%)	2,324 (23.7%)
Second richest	74,968 (23.5%)	7,327 (14.9%)	7,545 (20.9%)	2,112 (27.2%)	358 (15.2%)	2,301 (23.5%)
Richest	59,569 (18.7%)	4,558 (9.3%)	4,425 (12.2%)	3,022 (38.9%)	153 (6.5%)	2,357 (24.0%)
Hospital region						
Northeast	59,366 (18.4%)	7,504 (15.0%)	5,885 (15.9%)	1,495 (19.0%)	110 (4.4%)	2,986 (29.7%)
Midwest	79,703 (24.6%)	9,481 (19.0%)	2,485 (6.7%)	835 (10.6%)	463 (18.4%)	1,141 (11.3%)
South	140,244 (43.4%)	29,548 (59.1%)	16,854 (45.7%)	1,389 (17.6%)	865 (34.4%)	4,034 (40.1%)
West	44,166 (13.7%)	3,436 (6.9%)	11,697 (31.7%)	4,156 (52.8%)	1,078 (42.9%)	1,906 (18.9%)
Lifestyle factors						
Smoking history	135,628 (41.9%)	20,164 (40.4%)	10,157 (27.5%)	1,849 (23.5%)	1,028 (40.9%)	3,106 (30.9%)
Obesity	48,004 (14.8%)	10,188 (20.4%)	6,087 (16.5%)	490 (6.2%)	431 (17.1%)	1,377 (13.7%)
Drug abuse	9,381 (2.9%)	2,636 (5.3%)	1,302 (3.5%)	95 (1.2%)	173 (6.9%)	294 (2.9%)
Alcohol abuse	8,559 (2.7%)	2,010 (4.0%)	886 (2.4%)	84 (1.1%)	192 (7.6%)	228 (2.3%)
Comorbidities, n (%)						
Hypertension, complicated	99,087 (30.6%)	16,823 (33.7%)	8,963 (24.3%)	2,181 (27.7%)	640 (25.4%)	2,617 (26.0%)
Hypertension, uncomplicated	127,775 (39.5%)	20,413 (40.9%)	14,692 (39.8%)	3,398 (43.2%)	898 (35.7%)	4,019 (39.9%)
Diabetes with chronic complications	57,957 (17.9%)	11,993 (24.0%)	8,543 (23.1%)	1,738 (22.1%)	596 (23.7%)	2,021 (20.1%)
Diabetes without chronic complications	41,487 (12.8%)	8,019 (16.1%)	6,919 (18.7%)	1,500 (19.1%)	458 (18.2%)	1,664 (16.5%)
Metastatic cancer	9,670 (3.0%)	1,593 (3.2%)	932 (2.5%)	353 (4.5%)	53 (2.1%)	322 (3.2%)
Cerebrovascular disease	15,145 (4.7%)	3,688 (7.4%)	1,610 (4.4%)	441 (5.6%)	98 (3.9%)	522 (5.2%)
Liver disease, mild	11,907 (3.7%)	2,238 (4.5%)	1,988 (5.4%)	370 (4.7%)	194 (7.7%)	434 (4.3%)

Liver disease, severe	1,850 (0.6%)	201 (0.4%)	352 (1.0%)	48 (0.6%)	43 (1.7%)	71 (0.7%)
Renal failure, moderate	51,989 (16.1%)	8,416 (16.8%)	4,515 (12.2%)	1,152 (14.6%)	332 (13.2%)	1,344 (13.4%)
Renal failure, severe	8,385 (2.6%)	1,668 (3.3%)	889 (2.4%)	287 (3.6%)	85 (3.4%)	238 (2.4%)
Elixhauser comorbidity score, median (IQR)						
Mortality score	4 (18)	3 (18)	1 (15)	3 (17)	2 (16)	2 (16)
Readmission score	8 (9)	8 (11)	6 (10)	7 (10)	8 (10)	7 (10)

Appendix 17: Baseline characteristics by socioeconomic status among patients hospitalized with acute ACSCs (community acquired pneumonia and urinary tract infection)

n=440,399	Poorest n= 141,741	Second poorest n= 120,322	Second richest n= 96,313	Richest n= 75,032
Patient level characteristics, n (%)				
Age, mean ± SD	68.0 ± 17.1	70.2 ± 16.7	71.0 ± 16.7	72.9 ± 16.4
Sex				
Male	53,356 (37.7%)	45,931 (38.2%)	36,653 (38.1%)	28,671 (38.2%)
Female	88,376 (62.4%)	74,387 (61.8%)	59,658 (61.9%)	46,360 (61.8%)
Race				
White	91,947 (66.4%)	92,245 (79.0%)	74,968 (79.2%)	59,569 (80.4%)
Black	26,690 (19.3%)	10,548 (9.0%)	7,327 (7.7%)	4,558 (6.2%)
Hispanic	14,681 (10.6%)	9,536 (8.2%)	7,545 (8.0%)	4,425 (6.0%)
Asian or Pacific Islander	1,069 (0.8%)	1,570 (1.3%)	2,112 (2.2%)	3,022 (4.1%)
Native American	1,244 (0.9%)	606 (0.5%)	358 (0.4%)	153 (0.2%)
Other	2,826 (2.0%)	2,324 (2.0%)	2,301 (2.4%)	2,357 (3.2%)
Hospital region				
Northeast	13,950 (9.8%)	17,581 (14.6%)	20,209 (21.0%)	25,364 (33.8%)
Midwest	28,480 (20.1%)	33,161 (27.6%)	23,493 (24.4%)	12,633 (16.8%)
South	84,585 (59.7%)	52,530 (43.7%)	34,710 (36.0%)	21,217 (28.3%)
West	14,726 (10.4%)	17,050 (14.2%)	17,901 (18.6%)	15,818 (21.1%)
Lifestyle factors				
Smoking history	58,195 (41.1%)	48,811 (40.6%)	38,133 (39.6%)	27,359 (36.5%)
Obesity	23,199 (16.4%)	19,121 (15.9%)	15,080 (15.7%)	9,509 (12.7%)
Drug abuse	5,736 (4.1%)	3,634 (3.0%)	2,636 (2.7%)	1,528 (2.0%)
Alcohol abuse	4,354 (3.1%)	3,196 (2.7%)	2,511 (2.6%)	1,725 (2.3%)
Comorbidities, n (%)				
Hypertension, complicated	42,510 (30.0%)	36,887 (30.7%)	29,374 (30.5%)	22,313 (29.7%)
Hypertension, uncomplicated	56,398 (39.8%)	47,156 (39.2%)	38,253 (39.7%)	30,401 (40.5%)
Diabetes with chronic complications	29,079 (20.5%)	23,504 (19.5%)	18,253 (19.0%)	12,454 (16.6%)
Diabetes without chronic complications	21,785 (15.4%)	17,102 (14.2%)	12,553 (13.0%)	8,932 (11.9%)
Metastatic cancer	3,772 (2.7%)	3,508 (2.9%)	3,104 (3.2%)	2,602 (3.5%)
Cerebrovascular disease	7,225 (5.1%)	5,837 (4.9%)	4,770 (5.0%)	3,806 (5.1%)
Liver disease, mild	6,258 (4.4%)	4,561 (3.8%)	3,642 (3.8%)	2,520 (3.4%)
Liver disease, severe	933 (0.7%)	713 (0.6%)	523 (0.5%)	378 (0.5%)
Renal failure, moderate	21,311 (15.0%)	19,413 (16.1%)	15,594 (16.2%)	12,001 (16.0%)

Renal failure, severe	3,783 (2.7%)	3,285 (2.7%)	2,611 (2.7%)	1,963 (2.6%)
Elixhauser comorbidity score, median (IQR)				
Mortality score	3 (17)	3 (17)	4 (18)	4 (19)
Readmission score	8 (9)	8 (10)	7 (10)	7 (10)

Appendix 18: Baseline characteristics by hospital census region among patients hospitalized with acute ACSCs (community acquired pneumonia and urinary tract infection)

n=440,399	Northeast n= 77,934	Midwest n= 98,404	South n= 196,358	West n= 67,703
Patient level characteristics, n (%)				
Age, mean ± SD	71.1 ± 17.0	70.7 ± 16.7	69.5 ± 16.8	69.8 ± 17.3
Sex				
Male	30,556 (39.2%)	37,506 (38.1%)	73,476 (37.4%)	26,306 (38.9%)
Female	47,376 (60.8%)	60,896 (61.9%)	122,874 (62.6%)	41,392 (61.1%)
Race				
White	59,366 (76.8%)	79,703 (84.7%)	140,244 (72.7%)	44,166 (66.5%)
Black	7,504 (9.7%)	9,481 (10.1%)	29,548 (15.3%)	3,436 (5.2%)
Hispanic	5,885 (7.6%)	2,485 (2.6%)	16,854 (8.7%)	11,697 (17.6%)
Asian or Pacific Islander	1,495 (1.9%)	835 (0.9%)	1,389 (0.7%)	4,156 (6.3%)
Native American	110 (0.1%)	463 (0.5%)	865 (0.5%)	1,078 (1.6%)
Other	2,986 (3.9%)	1,141 (1.2%)	4,034 (2.1%)	1,906 (2.9%)
Median household income for patient's zip code				
Poorest	13,950 (18.1%)	28,480 (29.1%)	84,585 (43.8%)	14,726 (22.5%)
Second poorest	17,581 (22.8%)	33,161 (33.9%)	52,530 (27.2%)	17,050 (26.0%)
Second richest	20,209 (26.2%)	23,493 (24.0%)	34,710 (18.0%)	17,901 (27.3%)
Richest	25,364 (32.9%)	12,633 (12.9%)	21,217 (11.0%)	15,818 (24.2%)
Lifestyle factors				
Smoking history	30,521 (39.2%)	45,118 (45.9%)	74,591 (38.0%)	25,245 (37.3%)
Obesity	11,033 (14.2%)	17,541 (17.8%)	29,692 (15.1%)	9,609 (14.2%)
Drug abuse	2,423 (3.1%)	2,431 (2.5%)	5,997 (3.1%)	3,257 (4.8%)
Alcohol abuse	2,292 (2.9%)	2,690 (2.7%)	5,002 (2.6%)	2,230 (3.3%)
Comorbidities, n (%)				
Hypertension, complicated	22,610 (29.0%)	32,119 (32.6%)	59,074 (30.1%)	19,151 (28.3%)
Hypertension, uncomplicated	30,920 (39.7%)	37,696 (38.3%)	80,444 (41.0%)	25,755 (38.0%)
Diabetes with chronic complications	13,465 (17.3%)	19,800 (20.1%)	38,501 (19.6%)	12,774 (18.9%)
Diabetes without chronic complications	11,165 (14.3%)	12,897 (13.1%)	28,342 (14.4%)	8,988 (13.2%)
Metastatic cancer	2,592 (3.3%)	3,039 (3.1%)	5,547 (2.8%)	2,018 (3.0%)
Cerebrovascular disease	3,825 (4.9%)	4,725 (4.8%)	10,057 (5.1%)	3,350 (5.0%)
Liver disease, mild	2,990 (3.8%)	3,458 (3.5%)	7,783 (4.0%)	3,206 (4.7%)
Liver disease, severe	388 (0.5%)	509 (0.5%)	1,208 (0.6%)	503 (0.7%)
Renal failure, moderate	11,728 (15.1%)	17,630 (17.9%)	29,302 (14.9%)	10,597 (15.7%)

Renal failure, severe	2,085 (2.7%)	2,893 (2.9%)	5,111 (2.6%)	1,701 (2.5%)
Elixhauser comorbidity score, median (IQR)				
Mortality score	4 (18)	4 (17)	3 (17)	3 (17)
Readmission score	7 (10)	8 (10)	7 (10)	7 (10)

Appendix 19: Unadjusted odds ratios [95% confidence intervals] and P values for exposures of interest (race, quartiles of median household income for patient's ZIP code, and hospital region) for each ACSC

Variables	Diabetes Related Complications	COPD in Elderly	Hypertension	Heart Failure	Community Acquired Pneumonia	UTI	Asthma in Younger Adults
Race							
White				*Reference Category*			
Black	1.92 [1.90-1.94] *p*<0.001	0.93 [0.92-0.94] *p*<0.001	3.57 [3.51-3.62] *p*<0.001	1.52 [1.51-1.53] *p*<0.001	0.66 [0.66-0.67] *p*<0.001	0.71 [0.70-0.73] *p*<0.001	3.97 [3.81-4.13] *p*<0.001
Hispanic	1.43 [1.42-1.45] *p*<0.001	0.52 [0.51-0.53] *p*<0.001	1.48 [1.45-1.52] *p*<0.001	0.76 [0.75-0.77] *p*<0.001	0.60 [0.59-0.61] *p*<0.001	0.78 [0.76-0.79] *p*<0.001	2.28 [2.17-2.40] *p*<0.001
Asian or Pacific Islander	0.77 [0.75-0.79] *p*<0.001	0.57 [0.56-0.59] *p*<0.001	1.58 [1.51-1.65] *p*<0.001	0.82 [0.81-0.84] *p*<0.001	0.69 [0.67-0.71] *p*<0.001	0.64 [0.61-0.66] *p*<0.001	0.84 [0.73-0.97] *p*<0.05
Native American	1.59 [1.53-1.65] *p*<0.001	0.74 [0.70-0.78] *p*<0.001	1.02 [0.92-1.13] *p*=0.66	0.76 [0.73-0.79] *p*<0.001	0.75 [0.71-0.79] *p*<0.001	0.76 [0.71-0.81] *p*<0.001	1.46 [1.18-1.80] *p*<0.001
Unspecified	1.04 [1.02-1.06] *p*<0.05	0.56 [0.54-0.58] *p*<0.001	1.43 [1.37-1.49] *p*<0.001	0.76 [0.75-0.78] *p*<0.001	0.65 [0.63-0.67] *p*<0.001	0.72 [0.69-0.74] *p*<0.001	1.77 [1.61-1.94] *p*<0.001
Median household income quartile for patient's ZIP Code							
Richest				*Reference Category*			
Second richest	1.23 [1.21-1.24] *p*<0.001	1.27 [1.26-1.29] *p*<0.001	1.15 [1.12-1.18] *p*<0.001	1.09 [1.08-1.10] *p*<0.001	1.12 [1.10-1.13] *p*<0.001	1.00 [0.98-1.01] *p=0.60*	1.25 [1.18-1.33] *p*<0.001
Second poorest	1.39 [1.37-1.40] *p*<0.001	1.50 [1.48-1.52] *p*<0.001	1.21 [1.18-1.23] *p*<0.001	1.15 [1.14-1.16] *p*<0.001	1.23 [1.21-1.25] *p*<0.001	1.02 [1.01-1.04] *p*<0.05	1.43 [1.35-1.52] *p*<0.001
Poorest	1.54 [1.52-1.55] *p*<0.001	1.83 [1.81-1.86] *p*<0.001	1.31 [1.28-1.34] *p*<0.001	1.23 [1.22-1.24] *p*<0.001	1.33 [1.31-1.35] *p*<0.001	1.08 [1.07-1.10] *p*<0.001	1.62 [1.53-1.71] *p*<0.001
Region of hospital							
Northeast				*Reference Category*			
Midwest	0.94 [0.91-0.96] *p*<0.001	0.89 [0.84-0.94] *p*<0.001	0.95 [0.91-0.99] *p*<0.05	0.97 [0.93-1.00] *p=0.06*	1.27 [1.19-1.35] *p*<0.001	1.04 [0.99-1.10] *p=0.12*	0.75 [0.70-0.81] *p*<0.001
South	1.07 [1.04-1.10] *p*<0.001	0.91 [0.86-0.96] *p*<0.001	1.12 [1.08-1.17] *p*<0.001	0.98 [0.95-1.01] *p=0.21*	1.25 [1.18-1.33] *p*<0.001	1.25 [1.19-1.31] *p*<0.001	0.62 [0.58-0.66] *p*<0.001
West	0.96 [0.93-0.99] *p*<0.05	0.66 [0.62-0.70] *p*<0.001	0.84 [0.80-0.88] *p*<0.001	0.90 [0.87-0.94] *p*<0.001	0.90 [0.84-0.96] *p*<0.05	0.81 [0.77-0.86] *p*<0.001	0.79 [0.73-0.85] *p*<0.001

Appendix 20: Multinomial logistic regression analyses results (relative risk ratios [95% confidence intervals] and P values) for exposures of interest (race, quartiles of median household income for patient's ZIP code, and hospital region) for each type of ACSC as outcome

Variables	Non-ACSCs	Diabetes Related Complications	COPD in Elderly	Hypertension	Heart Failure	Community Acquired Pneumonia	UTI	Asthma in Younger Adults
Race								
White					*Reference Category*			
Black		1.72 [1.71-1.74]	1.40 [1.39-1.42]	3.95 [3.89-4.02]	1.72 [1.71-1.73]	0.91 [0.90-0.92]	1.06 [1.04-1.08]	2.79 [2.69-2.90]
		p<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001
Hispanic		1.43 [1.42-1.45]	0.98 [0.97-0.99]	1.86 [1.82-1.90]	1.15 [1.13-1.16]	0.95 [0.93-0.96]	1.22 [1.20-1.24]	1.31 [1.25-1.38]
		p<0.001	*p*<0.05	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001
Asian or	*Base*	0.84 [0.82-0.86]	1.07 [1.04-1.11]	1.85 [1.77-1.93]	1.08 [1.06-1.10]	0.91 [0.88-0.93]	0.78 [0.75-0.81]	0.70 [0.61-0.81]
Pacific	*Outcome*	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001
Islander								
Native		1.43 [1.38-1.48]	0.89 [0.85-0.94]	1.17 [1.06-1.29]	0.90 [0.87-0.94]	0.94 [0.89-0.99]	1.05 [0.98-1.12]	0.93 [0.76-1.15]
American		*p*<0.001	*p*<0.001	*p*<0.05	*p*<0.001	*p*<0.05	*p*=0.14	*p*=0.53
Unspecified		1.07 [1.05-1.09]	0.96 [0.94-0.99]	1.75 [1.68-1.82]	1.08 [1.06-1.10]	0.94 [0.91-0.97]	1.04 [1.01-1.07]	1.19 [1.09-1.31]
		p<0.001	*p*<0.05	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.05	*p*<0.001
Median household income quartile for patient's ZIP Code								
Richest					*Reference Category*			
Second richest		1.19 [1.18-1.21]	1.22 [1.20-1.23]	1.17 [1.14-1.20]	1.08 [1.07-1.08]	1.10 [1.08-1.11]	1.00 [0.99-1.02]	1.07 [1.01-1.14]
	Base	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*=0.77	*p*<0.05
Second	*Outcome*	1.30 [1.28-1.31]	1.36 [1.34-1.38]	1.23 [1.20-1.26]	1.11 [1.10-1.12]	1.15 [1.14-1.17]	1.01 [0.99-1.02]	1.14 [1.07-1.20]
poorest		*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*=0.27	*p*<0.001
Poorest		1.37 [1.36-1.39]	1.59 [1.57-1.61]	1.31 [1.28-1.34]	1.14 [1.13-1.15]	1.20 [1.19-1.22]	1.07 [1.06-1.09]	1.25 [1.18-1.32]
		p<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001
Region of hospital								
Northeast					*Reference Category*			
Midwest		0.87 [0.86-0.88]	0.74 [0.73-0.75]	0.91 [0.89-0.93]	0.82 [0.81-0.83]	0.92 [0.91-0.94]	0.93 [0.91-0.94]	0.62 [0.59-0.65]
	Base	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001
South	*Outcome*	1.03 [1.02-1.04]	0.85 [0.85-0.86]	1.10 [1.08-1.13]	0.98 [0.97-0.98]	1.07 [1.05-1.08]	1.10 [1.09-1.12]	0.57 [0.54-0.59]
		p<0.05	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001
West		0.96 [0.94-0.97]	0.65 [0.64-0.65]	0.85 [0.83-0.87]	0.89 [0.88-0.90]	0.83 [0.82-0.85]	0.79 [0.78-0.80]	0.73 [0.69-0.77]
		p<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001	*p*<0.001
Year								
2018					*Reference Category*			
2019		1.03 [1.02-1.04]	0.95 [0.94-0.96]	1.03 [1.02-1.05]	1.00 [0.99-1.01]	0.98 [0.97-0.99]	0.98 [0.97-0.99]	1.00 [0.96-1.04]
	Base	*p*<0.001	*p*<0.001	*p*<0.001	*p*=0.77	*p*<0.001	*p*<0.001	*p*=0.99

2020	*Outcome*	1.02 [1.01-1.03] *p*<0.001	0.65 [0.65-0.66] *p*<0.001	0.92 [0.91-0.94] *p*<0.001	0.88 [0.88-0.89] *p*<0.001	0.80 [0.79-0.81] *p*<0.001	0.84 [0.83-0.85] *p*<0.001	0.68 [0.65-0.71] *p*<0.001
Covariates								
Age	*Base Outcome*	0.99 [0.99-0.99] *p*<0.001	1.04 [1.04-1.04] *p*<0.001	1.02 [1.02-1.02] *p*<0.001	1.04 [1.04-1.04] *p*<0.001	1.03 [1.03-1.03] *p*<0.001	1.04 [1.04-1.04] *p*<0.001	0.91 [0.91-0.91] *p*<0.001
Sex								
Female					*Reference Category*			
Male	*Base Outcome*	2.13 [2.11-2.14] *p*<0.001	0.70 [0.70-0.71] *p*<0.001	1.05 [1.04-1.07] *p*<0.001	1.25 [1.24-1.26] *p*<0.001	1.01 [1.01-1.02] *p*<0.05	0.46 [0.46-0.47] *p*<0.001	1.41 [1.35-1.46] *p*<0.001
Hospital location/ teaching status	*Base Outcome*	0.86 [0.85-0.86] *p*<0.001	0.70 [0.69-0.70] *p*<0.001	0.92 [0.91-0.93] *p*<0.001	0.81 [0.81-0.82] *p*<0.001	0.61 [0.61-0.61] *p*<0.001	0.72 [0.72-0.73] *p*<0.001	0.90 [0.88-0.93] *p*<0.001
Lifestyle factors								
Smoking history		1.06 [1.05-1.07] *p*<0.001	4.72 [4.68-4.76] *p*<0.001	1.14 [1.12-1.16] *p*<0.001	1.32 [1.32-1.33] *p*<0.001	1.65 [1.63-1.66] *p*<0.001	0.91 [0.90-0.92] *p*<0.001	2.77 [2.67-2.87] *p*<0.001
Obesity		1.01 [1.00-1.02] *p=0.05*	1.27 [1.25-1.28] *p*<0.001	1.18 [1.16-1.20] *p*<0.001	2.33 [2.32-2.35] *p*<0.001	0.99 [0.98-1.00] p=0.23	0.91 [0.90-0.92] *p*<0.001	1.96 [1.88-2.05] *p*<0.001
Drug abuse	*Base Outcome*	0.38 [0.37-0.39] *p*<0.001	0.92 [0.91-0.94] *p*<0.001	0.88 [0.86-0.91] *p*<0.001	0.72 [0.71-0.73] *p*<0.001	0.79 [0.77-0.81] *p*<0.001	1.32 [1.27-1.36] *p*<0.001	1.24 [1.16-1.32] *p*<0.001
Alcohol abuse		0.43 [0.42-0.44] *p*<0.001	0.85 [0.84-0.87] *p*<0.001	0.70 [0.68-0.72] *p*<0.001	0.51 [0.50-0.51] *p*<0.001	0.58 [0.57-0.60] *p*<0.001	0.70 [0.68-0.72] *p*<0.001	0.38 [0.34-0.43] *p*<0.001
Elixhauser comorbidity score								
Mortality score	*Base Outcome*	0.96 [0.96-0.96] *p*<0.001	0.98 [0.98-0.98] *p*<0.001	0.98 [0.98-0.98] *p*<0.001	0.99 [0.99-0.99] *p*<0.001	0.99 [0.98-0.99] *p*<0.001	1.01 [1.01-1.01] *p*<0.001	0.97 [0.97-0.97] *p*<0.001
Readmission score		1.09 [1.09-1.09] *p*<0.001	1.01 [1.01-1.02] *p*<0.001	1.03 [1.03-1.03] *p*<0.001	1.11 [1.11-1.11] *p*<0.001	1.03 [1.03-1.03] *p*<0.001	0.97 [0.97-0.97] *p*<0.001	0.93 [0.92-0.93] *p*<0.001

Appendix 21: Logistic regression analyses results for the PAH as outcome without expected primary payer and individual comorbid conditions

N=17,629,891	Odds ratios [95% confidence intervals] and *P* values
Age	1.02 [1.02-1.02] *P*<0.001
Sex	
Female	*Reference Category*
Male	1.09 [1.08-1.09] *P*<0.001
Race	
White	*Reference Category*
Black	1.57 [1.57-1.58] *P*<0.001
Hispanic	1.20 [1.19-1.21] *P*<0.001
Asian or Pacific Islander	0.99 [0.98-1.00] *P*=0.05
Native American	1.03 [1.01-1.05] *P*<0.05
Other	1.03 [1.02-1.05] *P*<0.001
Median household income quartile for patient's ZIP Code	
Richest	*Reference Category*
Second richest	1.10 [1.09-1.10] *P*<0.001
Second poorest	1.15 [1.14-1.16] *P*<0.001
Poorest	1.23 [1.23-1.24] *P*<0.001
Region of hospital	
Northeast	*Reference Category*
Midwest	0.89 [0.86-0.92] *P*<0.001
South	1.02 [0.99-1.05] *P*=0.25
West	0.87 [0.84-0.90] *P*<0.001
Year	
2018	*Reference Category*
2019	0.99 [0.98-0.99] *P*<0.001
2020	0.84 [0.84-0.84] *P*<0.001
Covariates	
Bed size of hospital	0.83 [0.83-0.84] *P*<0.001
Location/ teaching status of hospital	0.73 [0.73-0.73] *P*<0.001
Lifestyle factors	
Smoking history	1.51 [1.50-1.51] *P*<0.001
Obesity	1.41 [1.41- 1.42] *P*<0.001
Drug abuse	0.70 [0.69-0.70] *P*<0.001
Alcohol abuse	0.54 [0.53-0.54] *P*<0.001
Elixhauser comorbidity score	
Mortality score	0.99 [0.99-0.99] *P*<0.001
Readmission score	1.06 [1.06-1.06] *P*<0.001
NIS hospital number; var (_cons)	0.11 [0.10-0.11]

Curriculum Vitae

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