RURAL VERSUS URBAN DIFFERENCES IN HOSPITAL READMISSIONS, INPATIENT MORTALITY, AND COST AMONG COPD PATIENTS

by

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ABSTRACT

LANNY S. INABNIT. Rural Versus Urban Differences in Hospital Readmissions, Inpatient Mortality, and Cost Among COPD Patients (Under the direction of Dr. AHMED ARIF)

Objectives: Chronic obstructive pulmonary disease (COPD) affects about 30 million people in the United States. Focusing on COPD, the aims of my dissertation were to identify factors that impacted 30-day readmissions (article 1), inpatient mortality (article 2), and costs of care (article 3). Comorbidities were analyzed to determine their effects on all outcomes. I also assessed differences in nonmetropolitan (rural) and urban (metropolitan) areas of residence for all outcomes.

Methods: I used data from the 2016 Nationwide Readmission Database (NRD) for articles 1 and 3 and the 2016 National (Nationwide) Inpatient Sample (NIS) database for article 2. I used: descriptive statistics to report mean (standard deviation) for continuous variables, the Chi-square test for categorical variables was used for mortality, and unadjusted and multiple logistic regression was used for odds ratios. The generalized linear model (GLM) was used for the adjusted analysis of total average cost and margins command was used to determine differences in total average cost. Comorbidities were assessed using the Elixhauser Comorbidities software. Nonmetropolitan status was used as an interaction term to determine if differences occurred between nonmetropolitan and metropolitan areas of residence.

Results: In article 1, I found that patients living in metropolitan areas had higher 30-day readmission rates. Patients with a length of stay greater than 4 days had a 24% increase in readmission rates. Males were more likely to be readmitted than females. Patients living in nonmetropolitan areas who received Worker's Compensation, or were enrolled in CHAMPUS, CHAMPVA, and other governmental programs had a higher readmission rate. Patients with

COPD in nonmetropolitan areas with cardiac arrhythmias, solid tumor without metastasis, pulmonary circulation disorders, and peripheral vascular disorders had higher odds of readmission as compared to patients with COPD in metropolitan areas.

In article 2, patients who were 75+ had 3 times higher odds of inpatient mortality than those 40-54. Males had an 18% increase in odds of mortality compared to females. Patients with Medicaid, private insurance, Worker's Compensation, CHAMPUS, CHAMPVA had higher odds of mortality than those with Medicare. Being admitted to a large hospital was associated with increased mortality compared to being admitted to a small hospital. The odds of inpatient mortality differed by rural or urban residence if the patient also had metastatic cancer, pulmonary circulation disorders, or fluid and electrolyte imbalance.

In article 3, patients with a length of stay of 4 or more days had higher costs of care regardless of residence. Patients from nonmetropolitan areas in the three highest household income categories had higher costs compared to those living in metropolitan areas. Readmission within 30 days was associated with higher total costs for patients from nonmetropolitan and metropolitan areas. Patients who also had congestive heart failure and uncomplicated hypertension who lived in nonmetropolitan areas had higher costs. Patients living in nonmetropolitan areas who had coagulopathy had higher costs.

Discussion: I examined three outcomes that have the largest impact on the health of patients diagnosed with COPD. It would be useful to use future years of the NRD and NIS to determine if the outcomes found in this dissertation exist or if there is a shift to new variables that are impacting outcomes. It will be especially useful to examine the effects that COVID-19 has had on outcomes for patients with COPD.

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DEDICATION

I dedicate this work to my family who have supported me throughout this process. I also dedicate this work to all those suffering from chronic obstructive pulmonary disease. My hope is that the findings in this research will help to improve the quality of life in these patients.

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LIST OF ABBREVIATIONS

AHRQ	Agency for Healthcare Research and Quality
AECOPD	Acute Exacerbation of COPD
BMI	Body Mass Index
CDC	Centers for Disease Control & Prevention
COPD	Chronic Obstructive Pulmonary Disease
FQHCs	Federally Qualified Health Centers
GLM	Generalized Linear Model
HRSA	Health Resources & Services Administration
HCUP	Healthcare Cost & Utilization Project
ICD-10-CM	International Classification of Disease, Tenth Revision, Clinical Modifications
LOS	Length of Stay
NCHS	National Center for Health Statistics
NIS	National (Nationwide) Inpatient Sample
NRD	Nationwide Readmissions Database
RUCA	Rural-Urban Commuting Area
SD	Standard Deviation
U.S.	United States

INTRODUCTION

Overview and Descriptive Epidemiology

Chronic obstructive pulmonary disease (COPD) is the third leading cause of death in the United States (U.S.) and is responsible for about 126,000 deaths per year (Riley & Sciurba, 2019). It is estimated that between 64 and 210 million people worldwide have COPD (May & Li, 2015). In the U.S., approximately 30 million people have COPD, with a prevalence of 12% (Riley & Sciurba, 2019). The prevalence of COPD for people over 40 is 11.5% for men and 7.5% for women. In rural areas, the prevalence of COPD among men and women is about 11% and 6%, respectively (Ntritsos et al., 2018). In urban areas, the estimated prevalence is 13% and 8% among men and women, respectively (Ntritsos et al., 2018). Some studies, however, have reported the prevalence of COPD as high as 11% among women (Landis et al., 2014). Research shows that African American patients have a lower prevalence of COPD (Kamil et al., 2013). However, African American women have been shown to have higher COPD-related death rates (Ni & Xu, 2016).

Hospital readmissions

COPD significantly burdens the healthcare system (Jinjuvadia et al., 2017). Hospitals are tasked with developing programs that focus on high-risk patients to help decrease readmissions (Press et al., 2019). Between 10% and 55% of COPD readmissions after an initial admission are preventable (Shah et al., 2016). Hospital readmissions, defined as an intensification of treatment management, have increased by approximately 60% over the last decade (Papanicolas et al., 2018), and account for nearly one-fourth of the overall direct costs associated with COPD. There is evidence that 30-day COPD readmission rates are significantly lower among patients living in metropolitan areas than those residing in nonmetropolitan areas (Croft et al., 2018; Jacobs et al.,

2018). Community- and household-level poverty is strongly associated with COPD prevalence and may contribute to the urban-rural disparity (Raju et al., 2019).

Approximately 8% of hospitalized patients with COPD are readmitted within 30 days of discharge (Lau et al., 2017). The 30-day hospital readmission rates are higher among those aged 40-64, African Americans, and those on Medicaid (Lau et al., 2017). Using six years of Healthcare Cost and Utilization Project (HCUP) data from eight U.S. states, Goto et al., reported all-cause 30-day readmission rates of 19% (2017). Non-Hispanic blacks were more likely to be readmitted due to respiratory diseases compared to non-Hispanic whites (Goto et al., 2017). The difference by race-ethnicity was in part attributed to factors such as lung physiology, access to pulmonary specialists, and lower socioeconomic status (Goto et al., 2017). Diseases such as cardiovascular disease, metabolic syndrome, skeletal muscle dysfunction, lung cancer, and depression are commonly related to COPD (Hillas et al., 2015). COPD patients with comorbidities such as alcohol abuse, anemia, depression, diabetes, drug abuse, and psychosis are more likely to be readmitted within 30 days of discharge (Lau et al., 2017).

Female patients with COPD are especially at risk of exacerbations, more hospitalizations, and a longer length of stay (Kilic et al., 2015), thus increasing the likelihood of adverse health outcomes. Women are more likely to develop chronic bronchitis and are more likely to suffer from certain comorbid conditions such as anxiety and depression (Raghavan et al., 2017; Aryal et al., 2013). Since 2000, the prevalence of COPD continues to rise in women, and mortality in women has outpaced mortality in men (Kamil et al., 2013). Minimizing barriers to access to care is a vital component for controlling exacerbations and readmissions among patients with COPD (Syed et al., 2013).

Patients with multiple comorbidities and those who had the highest Charlson index, which is a method of categorizing comorbidities, were shown to have higher readmission rates than patients with fewer comorbidities (Spece et al., 2018). Comorbidities, such as coronary heart disease, heart failure, lung cancer, depression, and obesity, increase the likelihood of COPD-related hospitalization and readmission (Cavailles, et al., 2013). Other respiratory conditions, such as pneumonia, also increase the risk of readmission (Bahadori et al., 2009).

Inpatient Mortality

An estimated 2.3% to 8.4% of all deaths in the U.S. are due to COPD (Rycroft et al., 2012). In-hospital mortality rates as high as 18.7% are reported among patients with COPD admitted to the intensive care unit with an acute exacerbation (Brown et al., 2018). Repeated hospitalization increased the likelihood of inpatient mortality (Abrams et al., 2011; Hartl et al., 2016; Pelkonen et al., 2017). Inpatient mortality is also high for patients who experienced a second severe exacerbation (Suissa et al., 2012). Patients with more comorbid conditions have higher mortality rates as compared to patients with fewer comorbid conditions (Spece et al., 2018).

In rural America, COPD is among the five leading causes of death (Burkes et al., 2018). The prevalence of COPD in rural, poor communities is nearly double that in the general population (Raju et al., 2019). Annual age-adjusted death rates from chronic respiratory disease have increased in rural counties in the past 35 years while decreasing in urban areas (Burkes et al., 2018).

The risk for mortality after hospitalization for COPD is high, especially in older males (Berry & Kalhan, 2015). Age and certain comorbid conditions are independent predictors of in-hospital mortality (Brown et al., 2018; Ho et al., 2014). Patients with COPD with at least one

comorbidity are more likely to have more exacerbations, a longer length of stay, and an increased risk of in-hospital mortality (Baty et al., 2013; Corlateanu et al., 2016). Intensive care unit length of stay and overall hospital length of stay increased the risk of inpatient mortality among patients with COPD (Brown et al., 2018).

Inpatient mortality is trending downward in patients who live in urban areas but has not improved in patients who live in rural areas (Villapiano et al., 2017). Patients living in rural areas have a 10% higher likelihood of dying in the hospital than patients in urban areas (Villapiano et al., 2017). A study by Moy et al. reported a moderate increase in death rates for people living in rural areas (2017). Even though overall mortality is trending downward, the gap between urban and rural populations has widened for most diseases, including COPD (Cosby et al., 2019).

Inpatient Cost

In the U.S., the annual economic costs associated with COPD are approximately $50 billion (Sullivan et al., 2018). Patients with COPD are considered high-cost patients due to the high utilization of inpatient and emergency services (Rinne et al., 2017), which represent about 60% of the total costs of care (Lee et al., 2017). The cost of overall care for COPD is associated with where patients receive care (Jahnz-Rózyk et al., 2009). Total cost of care for patients with COPD can be broken down into direct costs, such as medical and pharmacy costs (Dalal et al., 2010), and indirect costs, such as lost wages, missed days of work, and premature retirement due to illness (Wacker et al., 2016). Direct costs can be measured as attributable costs, such as hospitalizations, and excess costs, including the extra cost of having the disease over not having the disease (Ehteshami-Afshar et al., 2016). Studies have been conducted that look at the effects of readmissions in relation to cost and mortality (Amalakuhan et al., 2012; Johannesdottir et al., 2013; Prieto-Centurion et al., 2013). Amalakuhan et al. found that patients with a low body mass

index (BMI) had higher COPD mortality rates (2012). Mortality and readmission risk increased with subsequent exacerbations in patients with COPD (Johannesdottir et al., 2013). Patients with COPD with a household income in the lowest quartile had higher readmission rates than patients with COPD living in the highest quartile of income (Prieto-Centurion et al., 2013). A study conducted using the National Inpatient Sample (NIS) data from 2002-2010 reported increased readmissions in older white males with COPD, that inpatient mortality in patients with COPD declined from 4.8% to 3.9%, and that hospitalization costs increased by about $16,000 per hospitalization (Jinjuvadia et al., 2017).

A determining factor related to cost for patients diagnosed with COPD is exacerbations that led to readmissions (Villegas et al., 2021). Fortis et al. (2023) found that when adjusting for travel time to a Veteran's Affairs Medical Center, patients with COPD who lived in isolated rural areas had more frequent readmissions. Sridhara and Acharya (2021) determined that patients with COPD who also had multiple comorbidities had an increased likelihood of readmission compared to patients with COPD without comorbidities. Patients with COPD who have a household income in the lowest quartile had higher readmission rates than those in the highest quartile of income (Prieto-Centurion et al., 2013). Kirsch et al. (2019) found that patients with comorbidities had higher costs of care compared to patients without comorbidities.

Rurality

About 15% of the U.S. population lives in rural areas (Centers for Disease Control and Prevention [CDC], 2017). Rural populations are mostly white, poor, older, and more likely to die from heart disease, cancer, respiratory diseases, and stroke compared to people living in urban areas (The Chartis Center for Rural Health, 2020; Singh & Siahpush, 2014). Several studies have identified disparities in race, socioeconomic status, and environmental exposures in access to

healthcare between patients living in rural and urban areas (Drummond, 2014; Robertson et al., 2019). Evidence also shows that those living in rural areas tend to have lower life expectancy and overall quality of life (Linnen et al., 2018; Weeks et al., 2004). Compared with people who lived in urban areas, those who lived in rural areas had a higher risk of COPD exacerbation (Burkes et al., 2018) and higher COPD mortality rates (Singh & Siahpush, 2014).

Access to care and health care utilization plays a crucial role in determining the outcomes of patients with COPD. In rural areas, healthcare services are generally provided through rural health clinics and federally qualified health centers (FQHCs) (Rural Health Information Hub [RHIhub], N.D.b.). Most hospitals located in rural areas are classified as critical access hospitals (RHIhub, N.D.a.). Safety net hospitals are defined as hospitals that are mandated to provide care to vulnerable patients (Popescu et al., 2019). Both types of facilities have fewer resources that can be dedicated to managing patients with chronic diseases. Patients with COPD, especially female patients in these counties, have higher hospitalization rates (Jackson et al., 2011).

Access to physicians trained in pulmonary medicine has shown to increase the likelihood of an appropriate and timely diagnosis (Koblizek et al., 2016). Most counties with only rural health clinics lack access to pulmonary specialists and hospitals (Croft et al., 2016). Access to a pulmonologist was associated with lower readmission rates (Sharma et al., 2010). Patients living in rural areas travel further to seek medical help from qualified physicians trained in managing patients with COPD and may be required to seek services from a primary care physician who may not be well trained in managing COPD (Croft et al., 2016). A study of Swedish general practitioners revealed deficiencies in knowledge related to current management guidelines in COPD (Sandelowsky et al., 2018). A similar study in Mexico found a lack of utilization of evidence-based guidelines by primary care physicians in the management of COPD (Laniado-

Laborín et al., 2013). In the United States, physician adherence to current recommendations for the management of COPD has been reported as low (Perez et al., 2012; Salinas et al., 2011; Yawn & Wollan, 2008). The ability to see a pulmonary care specialist is vital in establishing clear and attainable goals in the management of this disease and reducing hospital utilization (Kim et al., 2016). It is important to identify issues with accessibility to quality care and how these affect overall readmission rates, inpatient mortality, and cost in patients with COPD.

For one of the studies in my dissertation research, I identified rurality by using a census level approximation of the rural-urban commuting area (RUCA) codes. The urban-rural designation of the hospital was based on the county as identified by the American Hospital Association (Healthcare Cost and Utilization Project [HCUP], N.D.a). Hospital urban-rural designation was categorized as large metropolitan greater than or equal to 1 million residents, small metropolitan areas with less than 1 million residents, micropolitan areas, and not metropolitan or micropolitan areas. I used metropolitan to represent urban status and nonmetropolitan to represent rural status.

In another study, I defined rurality based on the county as identified by the American Hospital Association (Healthcare Cost and Utilization Project [HCUP], N.D.b). Rurality was defined using a census-level approximation of the rural-urban commuting area (RUCA) codes. The National Center for Health Statistics developed a six-level scheme that helps define what is considered urban versus rural categories (CDC, 2013). I created the variable nonmetropolitan using the variable PL_NCHS (patient location: NCHS Urban-Rural Code) and using the values "5," which is micropolitan counties and the value "6," which is not-metropolitan and micropolitan counties. The variable metropolitan was created using the variable PL_NCHS and using the values "1" "Central" counties of metro areas of ≥ 1 million population, "2" "Fringe"

counties of metro areas of ≥ 1 million population, "3" Counties in metro areas of 250,000-999,999 population, and "4" counties in metro areas of 50,000-249,000 population (HCUP, n.d.b; Ingram & Franco, 2014). I then created a variable labeled nonmetropolitan by using nonmetropolitan equals 1, and the variable metropolitan was created by using nonmetropolitan equals 0. I defined nonmetropolitan as rural and metropolitan as urban.

Gaps in Literature and Significance of this Dissertation

More research is needed that focuses on outcomes comparing patients living in rural and urban areas and how hospital and individual-level factors differ. Lack of access to healthcare services for people living in rural areas make them vulnerable to adverse health outcomes, including readmissions and mortality (Brundisini et al., 2013). Over the last ten years, 95 rural hospitals, of which 32 were designated as critical access, have closed (Health Resources & Services Administration [HRSA], 2019). It is predicted that more closures will continue to occur. These closures may lead to more adverse consequences for people with COPD living in rural areas. Rural hospitals have been shown to serve patient populations with higher instances of chronic diseases (Mason, 2017). Readmission and mortality rates vary by gender and race. To what degree outcome related to gender and comorbidity vary by rurality and what role the cost of care plays, given concerns due to the closure of safety-net hospitals in rural areas, needs further investigation.

The overall burden of COPD on the healthcare system continues to be a top public health concern. It is important to determine if living in nonmetropolitan versus metropolitan areas is contributing to this continued burden. This dissertation will look at three pillars of social determinants of health: readmission rates, mortality, and hospital costs. By examining these three outcomes, I sought to identify associated demographic and hospital-level factors. It is my hope

that this dissertation research will help improve care management and outcomes among patients with COPD.

Dissertation Research

The purpose of my dissertation research was to identify nonmetropolitan and metropolitan differences in hospital readmissions and in-hospital mortality among patients with COPD. Further, I examined gender differences and the costs of hospitalization among patients with COPD living in nonmetropolitan versus metropolitan areas. There is limited literature available on assessing the adverse health outcomes in metropolitan-nonmetropolitan areas among patients with COPD. The results of this study will help fill the gap.

Article One: Rural urban differences in 30-day readmission rates among COPD patients

The aims of this study were to: 1) identify factors related to 30-day COPD readmissions; 2) determine differences in COPD readmission rates among patients living in nonmetropolitan areas and those living in metropolitan areas; and 3) explore the effects of comorbid conditions on COPD 30-day readmission rates and whether these effects vary by rurality.

It is important to continue to look for demographic factors that increase the likelihood of 30-day readmission in patients with COPD. Certain factors such as age, sex, insurance type, hospital bed size, and median household income were analyzed. I also stratified by nonmetropolitan versus metropolitan residence to look for differences. Finally, I analyzed individual comorbidities to determine their effect on readmission rates. By looking at these factors, I identified predisposing risk factors associated with 30-day readmissions.

Article Two: The Effects of Rurality on COPD Patients Related to Inpatient Mortality

The aims of this study were to: 1) identify demographic and other individual and hospital-level factors related to an increase in inpatient mortality; 2) compare inpatient mortality

among adults living in rural (nonmetropolitan) areas and those living in urban (metropolitan) areas; and 3) explore the effects of comorbid conditions on inpatient mortality and whether those effects vary by residence (nonmetropolitan versus metropolitan areas) among people with COPD. Results may help practitioners to identify patients with COPD who are at higher risk of inpatient mortality.

It is important to determine if certain demographic and hospital-level factors lead to an increased odds of mortality in patients with COPD. Factors such as age, sex, length of stay, insurance type, and median household income were analyzed. I also stratified by nonmetropolitan versus metropolitan residence to look for differences. Finally, I analyzed individual comorbidities to determine their effect on mortality. The goal was to determine if any of the factors predisposed patients with COPD to increased odds of mortality.

Article Three: The Effects of Rurality on COPD Patients Related to Average Cost of Care

The aims of this study were to 1) identify factors related to increased costs of COPD hospitalizations; 2) examine differences in hospital costs among patients living in nonmetropolitan areas and those living in metropolitan areas; and 3) explore the effects of comorbid conditions on costs and whether these effects vary by nonmetropolitan and metropolitan areas.

My overall objective in this study was to examine how individual and hospital-level factors are associated with hospital costs of patients with COPD. Factors such as age, sex, length of stay, insurance type, and median household income were analyzed. I also stratified by nonmetropolitan versus metropolitan residence to look for differences. Finally, I analyzed individual comorbidities to determine their effect on the overall cost of care. By determining

which factors have the largest impact on the cost of care, I can identify areas of needed resources.

ARTICLE 1: RURAL URBAN DIFFERENCES IN 30-DAY READMISSION RATES AMONG COPD PATIENTS

1.0 Introduction

Chronic obstructive pulmonary disease (COPD) is a preventable and treatable disease and a major health concern worldwide. In the United States (U.S.), more than 16 million people have been diagnosed with COPD (Hess et al., 2021; Croft et al., 2018), making it the third leading cause of death (Hess et al., 2021). An exacerbation, a common experience with COPD, is defined as seeking medical care for increased symptoms that require intensive medical management (Dalal et al., 2010). Exacerbations often lead to hospital admissions. COPD patients who are hospitalized are more likely to be readmitted within 30 days after discharge (Lau et al., 2017). Patients with COPD and other comorbidities are at particularly high risk of readmission (Speece et al., 2018; Cavailles et al., 2013; Bahadori et al., 2009; Kong & Wilkinson, 2020). Identifying factors associated with higher readmission rates could contribute to the development of more effective discharge care plans.

In rural America, COPD is among the five leading causes of death (Burkes et al., 2018). The prevalence of COPD in rural, poor communities is nearly double that in the general population (Raju et al., 2019). Annual age-adjusted death rates from chronic respiratory disease have increased in rural counties in the past 35 years, while decreasing in urban areas (Burkes et al., 2018). There is evidence that 30-day COPD readmission rates are significantly lower among patients living in metropolitan areas than among those residing in nonmetropolitan areas (Croft et al., 2018; Jacobs et al., 2018). Community and household poverty are strongly associated with COPD prevalence (Raju et al., 2019). Thus, poverty may contribute to the urban-rural disparity (Raju et al., 2019).

The aims of this study were to: 1) identify factors related to 30-day COPD readmissions; 2) determine differences in COPD readmission rates among patients living in nonmetropolitan areas and those living in metropolitan areas; and 3) explore the effects of comorbid conditions on COPD 30-day readmission rates and whether these effects vary by rurality.

1.1 Methods

1.1.1 Data Source

Data were from the 2016 Nationwide Readmissions Database (NRD) developed by the Healthcare Cost and Utilization Project (HCUP); these data were the most recent available when I began analysis in 2020. NRD represents 28 states and includes about 18 million annual discharges. The database has more than 100 clinical and non-clinical variables for each hospital stay. Hospital discharges are identified by state-specific linkage numbers but cannot be tracked across states (HCUP, n.d.a). These data include summary information from hospital discharges. NRD allows researchers to analyze national readmission rates for patients and their length of stay (HCUP, n.d.a). I used discharge weights to create national estimates.

1.1.2 Study Population

Most patients with COPD are diagnosed at age 40 or greater (Collison et al., 2018; Mannino et al., 2015; Schell et al., 2012). Thus, I included all patients aged 40 and older with the International Classification of Disease, Tenth Revision, Clinical Modification (ICD-10-CM) codes for acute exacerbation of COPD (AECOPD) in the analysis. Inclusion criteria were a diagnosis of COPD using the following ICD-10 codes: J40, J410, J411, J418, J42, J430, J431, J432, J438, J439, J440, J441, and J449. Patients were excluded if: 1) they had a missing identification number or a missing length of stay; 2) their hospitalizations led to a transfer to another acute care hospital, 3) they died during the index hospitalization; 4) the discharge month

was December due to the possibility of discharge in the next calendar year; or 5) the patient was transferred to another short-term care facility or the patient left against medical advice (Figure 1).

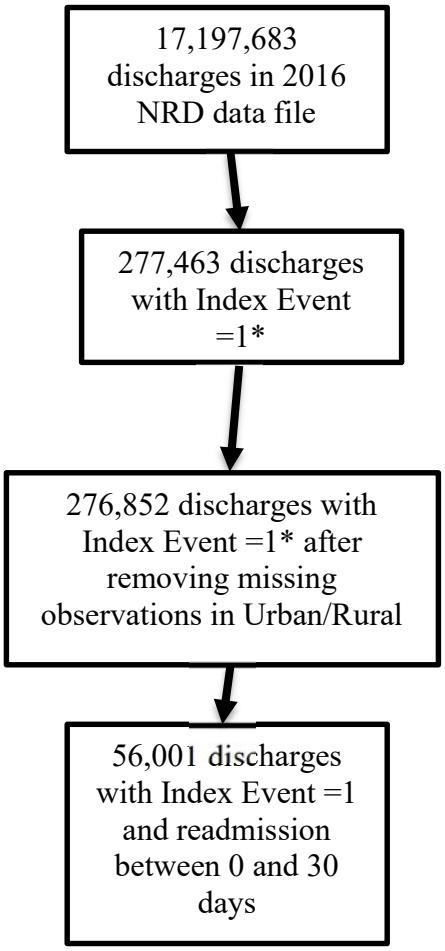

Figure 1. Study Flow Chart Diagram or Attrition Diagram

***Index Event-Patient has a diagnosis using ICD 10 codes from J40 through J449. The patient's age is greater than or equal to 40. The patient was discharged between January and November. The patient had a discharge status of routine, transfer to other facility, was discharged on home health care, or discharged alive but the destination unknown. The patient also had to maintain residence in the same state for one year.**

1.1.3 Outcome Measure

The outcome was COPD-related 30-day readmission. This measure was defined by index admissions for COPD with at least one subsequent COPD-related hospital readmission within 30 days (Jacobs et al., 2018; Jiang et al., 2018). An index admission was defined as a hospitalization that does not result in patient death (Jiang et al., 2018). Index hospitalizations were from January 1 to November 30, 2016, to capture all 30-day readmissions. December readmissions were excluded since this admission could go into the next calendar year. Patients who met the criteria for having an index event and were readmitted between 0 and 30 days were classified as readmission (Figure 1).

1.1.4 Covariates

Social, demographic, and clinical characteristics included in the analysis were age, length of stay (LOS), sex, insurance type, hospital bed size, urban/rural status as defined by metropolitan or nonmetropolitan, median household income quartiles, and total comorbid conditions. Age was categorized as 40-54, 55-64, 65-74, and 75 years or older. Insurance type was categorized as Medicare, Medicaid, private insurance, self-pay, no charge, and other. Median household income was categorized into the following quartiles: $1-$42,999, $43,000-$53,999, $54,000-$70,999, and $71,000+. I used the Elixhauser Comorbidities software provided by the Agency for Healthcare Research and Quality to identify major comorbidities for risk adjustment. For variables for which more than 0.1% were missing, I created dummy variables representing missing. For variables with less than 0.1% missing data points, I eliminated the patients from the analysis. The software creates 31 binary variables based on ICD-10 codes (Quan et al., 2005). Comorbidities were then broken into four nonoverlapping quartiles (Table 1).

1.1.5 Rurality

Rurality was defined by using a census level approximation of the rural-urban commuting area (RUCA) codes. The urban-rural designation of the hospital was based on the county as identified by the American Hospital Association (HCUP, n.d.a). Hospital urban-rural designation was categorized as large metropolitan greater than or equal to 1 million residents, small metropolitan areas with less than 1 million residents, micropolitan areas, and not metropolitan or micropolitan areas. I used metropolitan to represent urban status and nonmetropolitan to represent rural status.

1.1.6 Statistical Analysis

Descriptive statistics were reported as mean (standard deviation, SD) for continuous variables. Unweighted sum and weighted percentages were used to describe categorical variables. Binary logistic regression was used to determine the unadjusted odds ratios and 95% confidence intervals; multiple logistic regression was used to determine the adjusted odds ratios and 95% confidence intervals for the selected variables. I controlled for age, sex, insurance type, median household income, hospital bed size, nonmetropolitan status, hospital teaching status, and total comorbid conditions. Unadjusted and adjusted odds ratios were calculated for the following variables (reference group is listed in parentheses): age: (40-54 years), 55-64 years, 65-74 years, and 75+ years; sex: (female), male; length of stay was dichotomized as 0-3 days (reference) and 4+ days; insurance type: (Private), Medicare, Medicaid, Self-Pay, No Charge, and Other; median household income: ($71,000+), $1-$42,999, $43,000-$53,999, $54,000-$70,999; hospital bed size: (large), small, medium; residence: (nonmetropolitan), metropolitan; and comorbid conditions (Table 2). The outcome variable was 30-day readmission rates. Data were stratified by the metropolitan status and adjusted odds ratios of social, demographic, and

clinical characteristics were compared between metropolitan and nonmetropolitan residence. All analysis was performed using SAS version 9.4 and Stata 16.1, and significance levels were $p < 0.05$. The Office of Research Compliance at our university determined that this analysis did not require Institutional Review Board review.

1.2 Results

The mean age was 68.5 years (SD =11.6); the average length of stay was 4.3 days (SD=4.1). About 21% of the patients lived in a nonmetropolitan area. About 61% were 65 years old or greater. More than 70% were enrolled in Medicare and about 38% had a household income of less than $43,000. 38% of the patients had between 0 to 2 comorbid conditions, whereas 13.9% of the patients had 6+ comorbid conditions. The overall readmission rate was 20.2% (Table 1).

Table 1. Sociodemographic and Clinical Characteristics*

Characteristics	Unweighted (N)	Weighted (N)
Age (Years)		
Mean (SD)	68.5 (11.6)	
Readmission rate (%)	20.2	20
LOS (Days)		
Mean (SD)	4.3 (4.1)	4.2 (.01)
Median	3	
	Unweighted (N)	Weighted (%)
Age groups (Years)**		
40-54	34,683	12.9
55-64	72,416	26.5
65-74	81,012	29.2
75+	88,741	31.6
Sex***		
Male	116,347	41.9
Female	160,505	58.1
Insurance type**		
Medicare	195,211	70.7
Medicaid	38,975	13.6
Private	28,717	10.4
Self-pay	6,335	2.5
No charge	1,079	.4
Other (Worker's Compensation, VA, Indian Health Services)	6,226	2.2
Hospital Bed size***		
Small	53,031	21.6
Medium	88,154	29.8
Large	135,667	48.6
Urban-Rural***		
Metropolitan	229,075	78.9
Nonmetropolitan	47,777	21.1
Median Household Income Quartile		
$1 - 42,999	100,326	36.3
$43,000 - 53,999	74,731	27.0
$54,000 - 70,999	59,161	21.4
$71,000+	38,717	14.0
Median Household Income Missing	3,608	1.3
Comorbid Condition Quartiles (Number of Comorbidities)***		
1. (0-2)	105,416	38.1
2. (3)	54,605	19.8
3. (4-5)	78,000	28.2
4. (6-14)	38,522	13.9

***Data source: 2016 Nationwide Readmission Database; results of descriptive statistics**
****Missing values dropped**
*****No missing values**

Table 2 presents unadjusted and adjusted models for factors related to readmission among COPD patients. Patients with a length of stay more than 4 days had increased odds of readmission (adjusted odds ratio, OR: 1.24; 95% confidence interval, CI: 1.21-1.26). Patients

with Medicare (adjusted OR: 1.45; 95% CI: 1.39-1.51), Medicaid (adjusted OR: 1.61; 95% CI: 1.54-1.69), and Worker's Compensation, CHAMPUS, or CHAMPVA (adjusted OR: 1.36; 95% CI: 1.26-1.47) had increased odds of readmission. Those with household income of less than $43,000 had 11% increased odds of readmission (adjusted OR: 1.11; 95% CI: 1.07-1.15) compared to those with household income more than $75,000. Patients living in metropolitan areas had 10% higher odds of readmission (OR: 1.10; 95% CI: 1.06-1.16) than those living in nonmetropolitan areas. The number of comorbidities was associated with higher odds of readmission. Patients with 4-5 comorbid conditions had more than 1.3-fold odds of readmission (OR: 1.30; 95% CI: 1.26-1.34). Patients with 6+ comorbid conditions had 1.9-fold odds of readmission (OR: 1.88; 95% CI: 1.81-1.94). Males had higher odds of readmission. (Table 2).

Table 2. Unadjusted and Adjusted Odds Ratios for 30-day Readmission, by Selected Variables*

Characteristics	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age Groups (Year)**		
40-54	REF	REF
55-64	1.06 (1.02-1.10)	1.00 (0.96-1.03)
65-74	1.01 (0.97-1.04)	0.88 (0.85-0.92)
75+	0.99 (0.95-1.02)	0.83 (0.79-0.86)
Sex***		
Female	REF	REF
Male	1.14 (1.12-1.17)	1.17 (1.14-1.19)
Length of Stay***		
0-3 days	REF	REF
4+ days	1.35 (1.32-1.39)	1.24 (1.21-1.26)
Insurance Type**		
Medicare	1.52 (1.46-1.58)	1.45 (1.39-1.51)
Medicaid	1.81 (1.73-1.89)	1.61 (1.54-1.69)
Private	REF	REF
Self-Pay	0.93 (0.85-1.01)	0.95 (0.87-1.04)
No Charge	0.97 (0.81-1.18)	0.98 (0.82-1.19)
Other (Worker's Compensation, VA, Indian Health Services)	1.46 (1.35-1.57)	1.36 (1.26-1.47)
Median Household Income		
$ 1-$42,999	1.08 (1.04-1.11)	1.11 (1.07-1.15)
$43,000-$53,999	1.01 (0.98-1.04)	1.06 (1.02-1.09)
$54,000-$70,999	0.98 (0.94-1.02)	1.00 (0.97-1.04)
$71,000+	REF	REF
Median Household Income Missing	0.97 (0.88-1.07)	1.01 (0.92-1.12)
Hospital Bed Size***		
Small	0.86 (0.84-0.89)	0.93 (0.90-0.95)
Medium	0.99 (0.96-1.01)	1.01 (0.98-1.03)
Large	REF	REF
Nonmetropolitan	REF	REF
Metropolitan	1.19 (1.16-1.22)	1.10 (1.04-1.16)
Hospital Teaching Status***		
Metro Teaching	1.07 (1.05-1.10)	1.03 (1.01-1.05)
Non Metro Teaching	0.85 (0.83-0.88)	0.97 (0.91-1.03)
Comorbid Condition Quartiles (Number of Comorbidities)***		
1. (0-2)	0.73 (0.71-0.75)	0.75 (0.73-0.77)
2. (3)	REF	REF
3. (4-5)	1.33 (1.29-1.37)	1.30 (1.26-1.34)
4. (6-14)	1.95 (1.88-2.01)	1.88 (1.81-1.94)

***Data source: 2016 Nationwide Readmission Database; results of descriptive statistic**
**** missing data was dropped**
*****no missing data**

Table 3 shows adjusted odds ratios for COPD readmission rates stratified by hospital location (metropolitan versus nonmetropolitan). The odds ratio for the length of stay was similar in metropolitan and nonmetropolitan areas. Patients in age groups 65-74 and 75+ had significantly decreased odds of readmission in metropolitan areas than nonmetropolitan areas (p-

value for interaction ≤0.001). Patients with Medicaid had increased odds of readmission in metropolitan (OR: 1.58; 95% CI: 1.51-1.65) compared to nonmetropolitan areas (OR: 1.47; 95% CI: 1.32-1.65) (p-value for interaction term 0.01). Patients with other types of insurance, such as Worker's Compensation, CHAMPUS, CHAMPVA, Title V, and other government programs had significantly increased odds of readmission in nonmetropolitan than metropolitan areas (p-value interaction term 0.04) (Table 3). The interaction between length of stay and metropolitan/nonmetropolitan status was not statistically significant.

Table 3. Multiple Logistic Regression Analysis of Variables Stratified by Metropolitan/Nonmetropolitan Related to Readmission

Characteristics	Metropolitan Adjusted OR (95%CI)	Nonmetropolitan Adjusted OR (95%CI)	P-Value for Interaction Term*
Age Groups (Year)**			
40-54	REF	REF	REF
55-64	1.01 (0.97-1.05)	0.99 (0.91-1.08)	0.54
65-74	0.88 (0.84-0.91)	0.99 (0.90-1.08)	0.00
75+	0.81 (0.78-0.85)	0.93 (0.85-1.02)	0.00
Sex* **			
Male	1.17 (1.15-1.20)	1.17 (1.12-1.23)	0.85
Length of Stay (Days)* **			
0-3	REF	REF	
4+	1.22 (1.19-1.25)	1.21 (1.16-1.27)	0.72
Insurance Type**			
Medicare	1.42 (1.36-1.48)	1.43 (1.31-1.57)	0.41
Medicaid	1.58 (1.51-1.65)	1.47 (1.32-1.65)	0.01
Self-Pay	0.96 (0.88-1.05)	0.89 (0.73-1.09)	0.42
No Charge	1.06 (0.89-1.26)	0.18 (0.04-0.75)	0.02
Other (Worker's Compensation, VA, Indian Health Services)	1.28 (1.18-1.39)	1.51 (1.29-1.77)	0.04
Private	REF	REF	REF
Median Household Income			
$1-$42,999	1.11 (1.07-1.14)	1.02 (0.81-1.29)	0.35
$43,000-$53,999	1.04 (1.01-1.08)	1.03 (0.81-1.30)	0.80
$54,000-$71,000	1.00 (.96-1.03)	0.89 (0.70-1.14)	0.42
$ 71,000+	REF	REF	REF
Median Household Income Missing	1.04 (0.94-1.15)	0.76 (0.56-1.03)	0.10
Hospital Bed Size* **			
Small	0.94 (0.91-0.96)	0.91 (0.85-0.97)	0.05
Medium	1.01 (0.99-1.03)	0.98 (0.92-1.04)	0.32
Large	REF	REF	REF
Comorbid Condition Quartiles (Number of Comorbidities)* **			
1. (0-2)	0.76 (0.74-0.78)	0.72 (0.67-0.76)	0.10
2. (3)	REF	REF	REF
3. (4-5)	1.31 (1.28-1.36)	1.23 (1.15-1.32)	0.09
4. (6-14)	1.89 (1.83-1.95)	1.89 (1.75-2.05)	0.49

*** P-value for interaction was obtained by including the interaction term for nonmetropolitan variable separately with each variable**
**** missing data was dropped**
*****no missing data**

COPD patients with congestive heart failure and cardiac arrhythmias had 30% increased odds of readmission (adjusted OR: 1.30; 95% CI: 1.27-1.33; adjusted OR: 1.28; 95% CI: 1.25-1.33). COPD patients with paralysis had a 2.7-fold increase in readmission. Other comorbid conditions that were associated wither higher odds of readmissions included: neurologic disorders (adjusted OR: 1.61; 95% CI: 1.55-1.68), complicated diabetes (adjusted OR: 1.25; 95%

CI: 1.21-1.29), liver disease (adjusted OR: 1.29; 95% CI: 1.22-1.36), peptic ulcer disease (adjusted OR: 1.41; 95% CI: 1.26-1.57), lymphoma (adjusted OR: 1.38; 95% CI: 1.21-1.58), metastatic cancer (adjusted OR: 1.83; 95% CI: 1.67-2.01), weight loss (adjusted OR: 1.50; 95% CI: 1.45-1.57), fluid and electrolyte disorders (adjusted OR: 1.32; 95% CI: 1.29-1.35), blood loss anemia (adjusted OR: 2.19; 95% CI: 1.91-2.50), drug abuse (adjusted OR: 1.64; 95% CI: 1.57-1.72), and psychosis (adjusted OR: 1.30; 95% CI: 1.22-1.39) (Figure. 2).

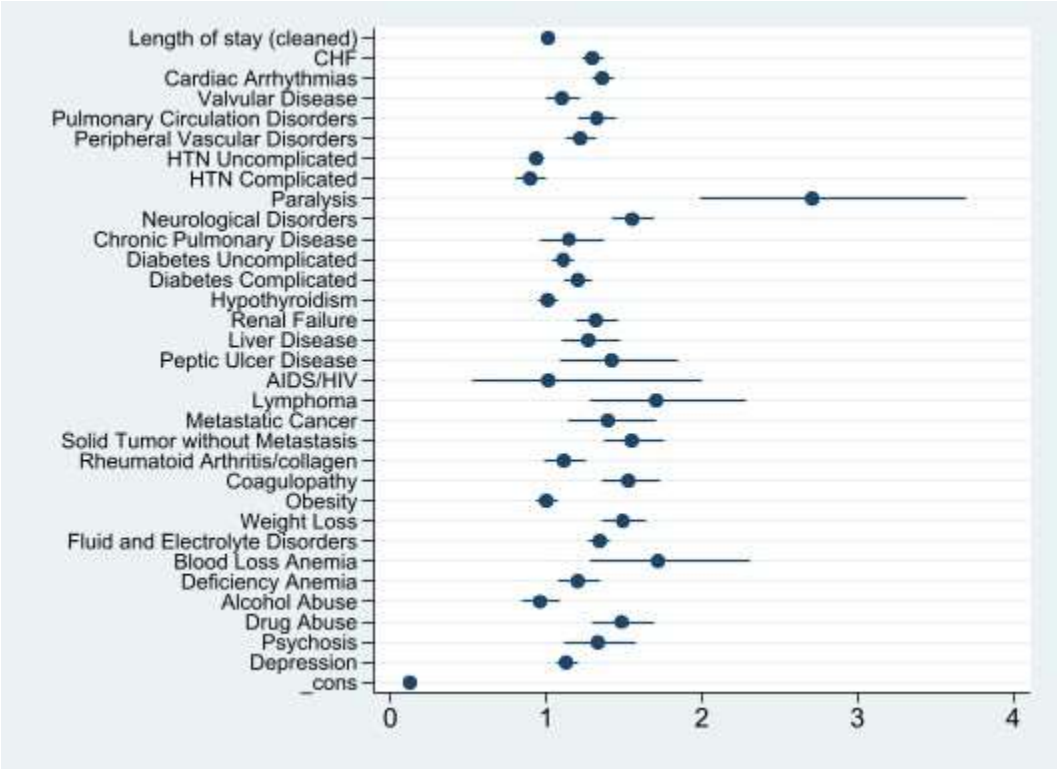

Figure 2. Adjusted Odds Ratios of Readmission by Variable

COPD patients living in metropolitan areas with neurologic disorders, uncomplicated and complicated diabetes, peptic ulcer disease, AIDS/HIV, metastatic cancer, blood loss anemia, alcohol abuse, and drug abuse had increased odds of readmission compared to patients living in nonmetropolitan areas. Patients living in nonmetropolitan areas with solid tumor with metastasis, renal failure, peripheral vascular disorders, pulmonary circulation disorders, valvular disease,

and cardiac arrhythmias had increased odds of readmission compared to patients living in metropolitan areas (Figure 3).

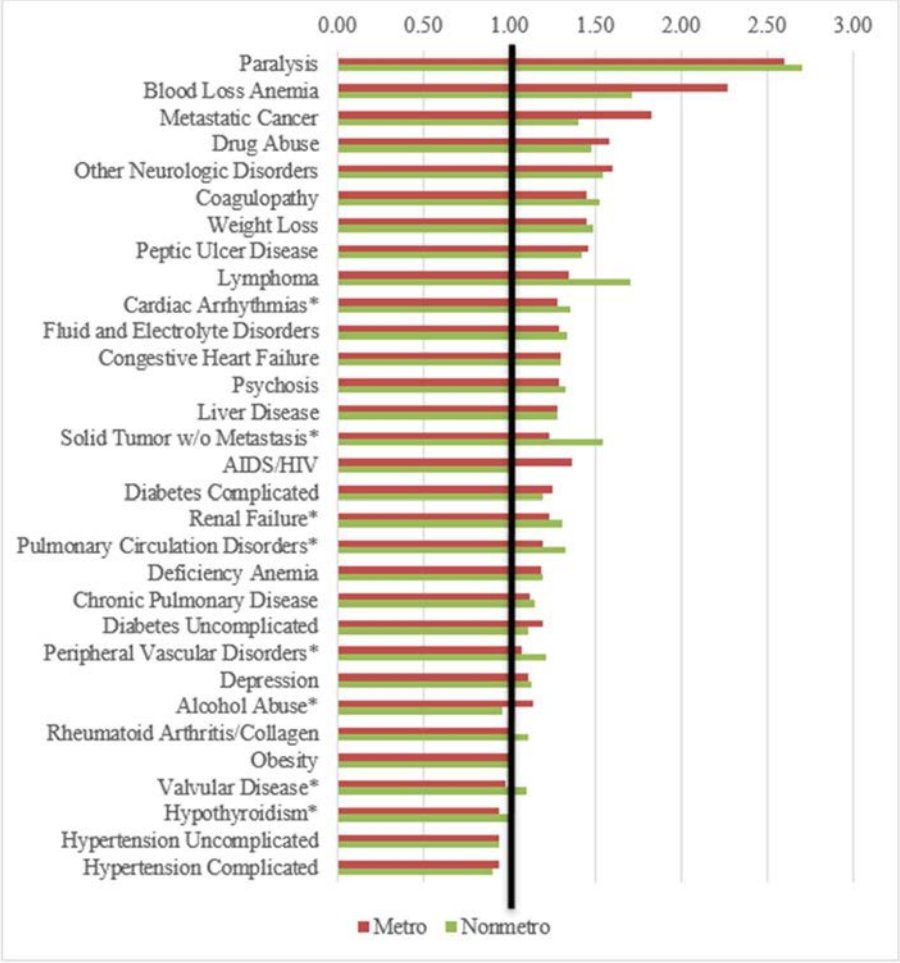

Figure 3. Adjusted Odds Ratio by Comorbidities (Metropolitan vs. Nonmetropolitan)

***Statistically significant differences between the effects of each comorbid condition and living in a nonmetropolitan area and the likelihood of readmission.**

1.3 Discussion

I identified risk factors for 30-day readmissions for patients diagnosed with COPD. Risk factors for all-cause hospital readmission included comorbidities, previous exacerbation and hospitalizations, increased length of stay, and male gender.

Results of the present study showed a higher readmission rate for patients living in metropolitan areas. Singh and Yu also found that patients in metropolitan areas were more likely

to be readmitted (2016). Other researchers found that people residing in areas defined as the most disadvantaged had a 98% higher rate of severe exacerbation (Alqahtani et al., 2020). COPD patients often have other comorbidities that require specialized care, which is often not available in rural areas. I hypothesized that higher readmission rates would be seen in patients living in nonmetropolitan areas. Patients who live in nonmetropolitan areas could be seeking care in metropolitan areas due to limited resources in nonmetropolitan areas. There may also be a disproportionate number of people living in disadvantaged metropolitan areas. People residing in areas defined as the most disadvantaged had 98% higher rate of a severe exacerbation (Galiatsatos et al., 2020). These findings have implications for access to care for patients with poor control of COPD and accompanying comorbidities.

I found several comorbid conditions including neurological, cardiovascular, and cancer were associated with increased readmission rates among COPD patients. Prior studies have identified comorbid conditions in COPD patients that was associated with an increase in readmission risks (Speece et al., 2018; Cavailles et al., 2013; Bahadori et al., 2009). COPD patients with comorbidities such as congestive heart failure, coronary artery disease, and diabetes had an increased likelihood of readmission (Speece et al., 2018). Diseases such as coronary heart disease, heart failure, lung cancer, and lung infections lead to worse outcomes in patients with COPD (Cavailles et al., 2013; Bahadori et al., 2009). Patients with COPD with coexisting congestive heart failure and osteoporosis have a greater risk of readmission (Kong & Wilkinson, 2020). In the present study I found similar increased odds of readmission for COPD patients who also had a diagnosis of congestive heart failure. Other comorbid conditions that had an effect on readmissions included neurologic disorders, complicated diabetes, peptic ulcer disease, metastatic cancer, blood loss anemia, drug abuse, and psychosis. Simmering et al. showed

similar results regarding the effects of certain comorbid conditions on readmission rates (2016). COPD patients with comorbidities such as alcohol abuse, anemia, depression, diabetes, drug abuse, and psychosis were more likely to be readmitted within 30 days of discharge (Lau et al., 2017). Patients with multiple comorbidities and those who had the highest Charlston index were shown to have higher readmission rates than patients with fewer comorbidities (Spece et al., 2018).

Patients with a length of stay greater than 4 days had a greater than 20% increase in readmission rates. Alqahtani et al. identified increased length of stay as a risk factor for all-cause hospital readmission (2020). Rinne et al. found a 2-fold increase in readmission rate in patients who had a length of stay greater than 4 days (2017). Thus, my results are consistent with the findings reported by these authors.

I found that males were more likely to be readmitted than females. Buja et al. found a 34% increase in odds of readmission for males with COPD (2020), consistent with the present study. Buja et al. hypothesized that this was likely due to males seeking less care for their disease upon discharge (2023). Also consistent with my results, Jo et al. (2020) and Goto et al. (2017) also reported that males with COPD were readmitted at a higher rate than females. Jo et al. (2020) and Goto et al. (2017) did not speculate why they thought males were more susceptible for readmission.

In the present study, patients who received Medicaid had an increased odds of readmission within 30 days. Simmering et al. showed similar increases in readmissions among patients younger than 65 years of age on Medicaid (2016). Simmering et al. speculate that this result may be due in part to more severe cases of COPD in younger patients and thus an increased risk of readmission (2016). Jiang et al. also reported that patients who received

Medicaid benefits had an increased odds of being readmitted (2018). Jiang et al. commented that this finding may be due to lack of policy and program focus on decreasing readmission rates in patients who receive Medicaid (2018).

I found a statistically significant difference in readmission rates among patients living in nonmetropolitan areas who received Worker's Compensation, or were enrolled in CHAMPUS, CHAMPVA, and other governmental programs. Patients with these insurance types living in nonmetropolitan areas had 23% increased odds of readmission compared to patients living in metropolitan areas. COPD patients who received Medicaid benefits also had a significant increase in readmission if they lived in metropolitan areas versus living in nonmetropolitan areas. It would be useful for future research to examine the associations between insurance types and rural and urban residence. A better understanding of these associations could improve access to care.

1.4 Strengths

The Nationwide Readmission Database (NRD) dataset allows for access to a robust sample of readmission data. The dataset allows for analysis of multiple patient conditions and various subgroups. The focus of the paper was to determine readmission rates for patients diagnosed with COPD and to also determine if differences exist in patients in nonmetropolitan versus metropolitan areas. COPD continues to have a huge burden on healthcare. This study supports the conclusion readmissions for COPD continue to be a burden on healthcare. Few researchers have studied what factors affect readmission rates in patients in nonmetropolitan areas versus metropolitan areas. Researchers should continue to use future NRD datasets to determine if trends found in this study continue to exist or if new trends are emerging.

1.5 Limitations

The NRD data include discharges from 28 states, limiting its generalizability. Miscoding and misdiagnosis can occur in hospital discharge data; however, HCUP data is quality checked and has a low percentage of missing data. Also, a disproportional percentage of patients live in nonmetropolitan areas. This limitation was noted in the analysis. Patients might seek care in metropolitan areas due to limited resources in nonmetropolitan areas which could lead to an underrepresentation of care being delivered in nonmetropolitan areas. Since NRD data is an annual sample, I cannot track discharges across multiple years. HCUP data also has limited clinical information which does not allow researchers to control for other health conditions, including limitations in activities of daily living and self-reported health. HCUP data does not provide patient level electronic medical records to provide a complete episode of care that could potentially lead to variables not identified in the study to lead to a readmission. This analysis was conducted prior to the COVID-19 pandemic; thus, leading causes of death have changed substantially (CDC, n.d.).

1.6 Conclusion

The most notable result of this study is the effect of comorbidities on readmission risk. Comorbid conditions such as cardiac arrhythmias, valvular disease, lymphoma, and blood loss anemia in metropolitan versus nonmetropolitan patients was associated with increased odds of readmission. It would be useful to further examine the effects of certain comorbid conditions on readmission rates to help identify patients at high risk of readmission. Doing so may help healthcare providers to intervene earlier and hospitals to direct their resources efficiently. It would also be useful to further explore the associations between comorbid conditions and rural and urban residence given my findings found that certain comorbid conditions, such as solid

tumor with metastasis, renal failure, peripheral vascular disorders, and pulmonary circulation disorders were associated with increased odds of readmission among patients living in nonmetropolitan areas. Although I did not find that living in nonmetropolitan areas was associated with readmission risk, this study identified certain variables, such as type of insurance and certain comorbid conditions that affect readmission rates among patients with COPD in nonmetropolitan areas.

The burden of chronic disease will continue to have a profound effect on the healthcare system. Thus, it is useful for researchers to look for common factors that are associated with increased readmission rates in patients with COPD especially patients in nonmetropolitan areas. A better understanding of readmission risk among rural and urban areas may help us more effectively allocate health care and social service resources.

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ARTICLE 2: THE EFFECTS OF RURALITY ON COPD PATIENTS RELATED TO INPATIENT MORTALITY

2.0 Introduction

Chronic obstructive pulmonary disease (COPD) affects more than 16 million people in the United States (Hess et al., 2021; Croft et al., 2018), making it the third leading cause of death (Hess et al., 2021). An estimated 2.3% to 8.4% of all deaths are due to COPD (Rycroft et al., 2012). In-hospital mortality rates as high as 18.7% were reported among patients with COPD admitted to the intensive care unit with an acute exacerbation, a common experience with COPD (Brown et al., 2018). Acute exacerbation is defined as seeking medical care for increased symptoms that require intensive medical management (Dalal et al., 2010; Brown et al., 2018). Repeated hospitalization increases the likelihood of inpatient mortality (Abrams et al., 2011; Hartl et al., 2016; Pelkonen et al., 2017). Patients with more comorbid conditions have higher inpatient mortality rates than those with fewer comorbid conditions (Spece et al., 2018). COPD is a progressive disease that develops after long-term exposure to things such as cigarette smoking, indoor air pollutants, and agricultural exposures. Raju et al. (2019) state that those exposures tend to be higher in rural communities.

Demographic characteristics, comorbid conditions, and length of stay are independent predictors of inpatient mortality (Brown et al., 2018; Ho et al., 2014). Patients with COPD who have at least one comorbidity are more likely to have more exacerbations, a longer length of stay, and an increased risk of inpatient mortality (Baty et al., 2013; Corlateanu et al., 2016). A longer length of intensive care unit and overall hospital length of stay is associated with a higher risk of inpatient mortality among patients with COPD (Brown et al., 2018).

Inpatient mortality may also be associated with rural or urban residence. Inpatient mortality decreased among people living in urban areas from 2008 to 2013 but did not decrease among those living in rural areas (Villapiano et al., 2017). In 2013, patients living in rural areas had a 10% higher risk of dying in the hospital than those in urban areas (Villapiano et al., 2017). Moy et al. (2017) investigated trends between metropolitan and nonmetropolitan areas related to the five leading causes of death and found that age-adjusted death rates for patients living in nonmetropolitan who had chronic lower respiratory disease increased over a 5-year span, from 2010 to 2014. During this same period, age-adjusted death rates for metropolitan patients with chronic lower respiratory disease also decreased (Moy et al., 2017).

For patients living in rural areas, COPD is among the five leading causes of death (Burkes et al., 2018). Some of the factors that have contributed to increasing rural and urban disparities include housing disparities and air pollution (Weinstein et al., 2017). Raju et al. (2019) reported that the prevalence of COPD was highest in poor, rural communities at 15.7% and lowest in urban, non-poor communities at 6.1%. Factors such as indoor heating sources such as coal and living in poverty are strongly associated with COPD prevalence (Raju et al., 2019).

The aims of this study were to: 1) identify demographic and other individual and hospital-level factors related to an increase in inpatient mortality; 2) compare inpatient mortality among adults living in rural (nonmetropolitan) areas and those living in urban (metropolitan) areas; and 3) explore the effects of comorbid conditions on inpatient mortality and whether those effects vary by residence (nonmetropolitan versus metropolitan areas) among people with COPD. Results may help practitioners to identify factors such as number of comorbid conditions that place patients with COPD at higher risk of inpatient mortality.

2.1 Methods

2.1.1 Data Source

I used the 2016 National (Nationwide) Inpatient Sample (NIS) dataset developed by the Agency for Healthcare Research and Quality (AHRQ) for the Healthcare Cost and Utilization Project (H-CUP). The NIS is designed to produce national and regional estimations of inpatient utilization, access, charges, and outcomes (HCUP, n.d.b). This database contains over 7 million hospital stays annually (HCUP, n.d.b). Forty-seven states and the District of Columbia participate in the HCUP project (HCUP, n.d.b). The NIS allows for a 20% stratified sample of all non-Federal hospitals in 47 states and District of Columbia. Hospital and discharge weights are used to approximate national estimates. These data include a patient identifier, hospital transfer data, demographic data, admission type, health insurance status, length of stay, total hospital charges, and primary and secondary diagnosis. Patient residence is determined by using the variable labeled PL_NCHS. PL_NCHS is a six-category urban-rural classification scheme for U.S. counties developed by the National Center for Health Statistics (NCHS) (https://hcup-us.ahrq.gov/db/vars/nisnote_multi.jsp).

2.1.2 Study Population and Outcome Measure

Most patients with COPD are diagnosed after the age of 40 (Collison et al., 2018; Mannino et al., 2015; Schell et al., 2012). Thus, I included all patients aged 40 and older with the International Classification of Disease, Tenth Revision, Clinical Modification (ICD-10-CM) codes for acute exacerbation of COPD in the analysis. Inclusion criteria were a diagnosis of COPD using the following ICD-10 codes: J40, J410, J411, J418, J42, J430, J431, J432, J438, J439, J440, J441, and J449 (Figure 4). The primary outcome of interest was all-cause inpatient mortality defined as “died” during the hospital encounter (coded 1 for died, 0 did not die during

hospitalization). Index hospitalizations were from January 1 to November 30, 2016, to capture all in-hospital mortality (Figure 4). In the NIS, patients cannot be followed from year to year. Therefore, December admissions were excluded due to the potential for in-hospital mortality to occur in 2017.

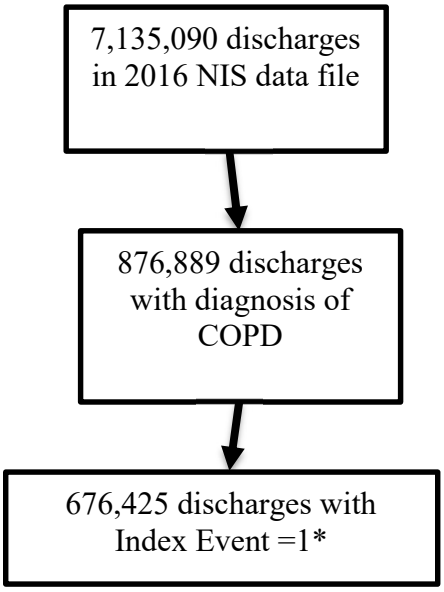

Figure 4. Study Flow Chart Diagram

***Index Event-Patient has a diagnosis using ICD 10 codes from J40 through J449.The patient's age is greater than or equal to 40. The patient was discharged between January and November. The patient also had to maintain residence in the same state for one year.**

2.1.3 Covariates

Nonmetropolitan area of residence was created using the variable PL_NCHS (patient location: NCHS Urban-Rural Code) and keeping values of micropolitan counties and nonmetropolitan or micropolitan counties. Metropolitan was defined as "central" counties of metro areas of ≥1 million population, "fringe" counties of metro areas of ≥1 million population, counties in metro areas of 250,000-999,999 population, and counties in metro areas of 50,000-249,000 population. I used the metropolitan classification to represent urban status and the nonmetropolitan classification to represent rural status.

Age was stratified into the following groups: 40-54, 55-64, 65-74, and 75+. Sex was coded as male and female. Insurance type was categorized as Medicare, Medicaid, private including HMO, self-pay, and other (Worker's Compensation, Veterans Affairs (VA), and Indian Health Services). Urban-rural status was classified by creating a rural (nonmetropolitan) variable based on the patient's location of residence.

Household income was categorized as $1-$42,999, $43,000-$53,999, $54,000-$70,999, and $71,000 or greater. Race was grouped as White, Black, Hispanic, Pacific Islander, Native American, and Other (multiple races). Hospital size by number of beds was designated as small, medium, and large. Hospital Division was stratified as New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific. The AHRQ provides Elixhauser Comorbidities software to identify major comorbidities for risk adjustment. The software creates 31 binary variables based on ICD-10 codes (Quan et al., 2005). For variables that had more than 0.1% missing data points, I created dummy variables representing missing. For variables with less than 0.1% missing data points, I eliminated the patients from the analysis.

2.1.4 Statistical Analysis

Descriptive statistics were reported as mean (standard deviation, SD) for continuous variables and unweighted frequency distribution, along with the weighted percentages for categorical variables. The dependent variable was death during hospitalization. In the bivariate analysis, I used the Chi-square test to determine the significance of the association between independent and dependent variables. Binary logistic regression was used to estimate the unadjusted odds ratios (OR) and 95% confidence intervals (CI) for age (55-64 years, 65-74 years, and ≥ 75 years), sex (female), insurance type (Medicaid, Private, Self-Pay, No Charge,

and Other), nonmetropolitan, median household income ($43,000-$53,999, $54,000-$70,999, $71,000+), race (Black, Hispanic, Pacific Islander, Native American, Other), hospital bed size (medium and large), hospital region (Northeast, Midwest, South, and West), and comorbid conditions. Length of stay was converted to a binary variable where 0-3 days and 4+ days were the categories. Multiple logistic regression was used to estimate the adjusted odds ratios and 95% confidence intervals adjusted for the covariates described in the passage above.

Lastly, to compare mortality between metropolitan and nonmetropolitan residence, odds ratios, adjusted for covariates, were estimated by including interaction terms between metropolitan and nonmetropolitan and individual covariates separately in the model (Table 4 and Table 5). All analyses were performed using Stata 16.1. A p-value of <0.05 identified significant results. The Office of Research Compliance at the University of North Carolina at Charlotte determined that this study did not require Institutional Review Board approval.

2.2 Results

There were 676,425 discharges in the final analytical sample (Figure 4). Table 4 reports descriptive statistics for the final sample. Mean age was 69.7 (SD=12.1); 37.2% of the patients were 75 years or older. About 80% lived in a metropolitan area. 604 patients had missing data regarding mortality which represented 0.09% of the total sample, and those patients were eliminated from the analysis. The inpatient mortality rate for patients from metropolitan areas was 4%; the corresponding rate for those from nonmetropolitan areas was 4.1%. Overall inpatient mortality was 4%. The difference in inpatient mortality rates for patients from metropolitan versus nonmetropolitan areas was not significant. About 52% of patients were female, and 73.1% had Medicare as their insurance coverage. About a third of patients had a

household income of $1-$42,999. Nearly 80% of patients reported race as White. Nearly 60% of patients had a length of stay of 4+ days. Average length of stay was 5.7 (SD 6.2) days.

Table 4. Sociodemographic and Clinical Characteristics*

Characteristics	Unweighted (N)	Weighted (%)
Age (Yrs.)		
Mean (SD)	69.7 (12.1)	69.7
Median	70	
LOS (Days)		
Mean (SD)	5.7 (6.2)	5.7
Median	4	
Mortality (%)	4	
Urban	4	
Rural	4.1	
Variables	**Unweighted (N)**	**Weighted (%)**
Age Groups (Years)**		
40-54	79,812	12.0
55-64	154,098	22.8
65-74	188,924	28.0
75+	251,954	37.2
Sex**		
Male	324,241	48.1
Female	350,547	51.9
Insurance type**		
Medicare	493,323	73.1
Medicaid	78,341	11.6
Private including HMO	74,669	11.1
Self-pay	12,501	1.9
No charge	1,217	.19
Other (Worker's Compensation, VA, Indian Health Services	14,737	2.2
Metropolitan-Nonmetropolitan**		
Metropolitan	542,243	80.4
Nonmetropolitan	132,545	19.6
Median Household Income Quartile		
$1 - $42,999	234,383	34.7
$43,000 - $53,999	182,603	27.1
$54,000 - $70,999	147,803	21.9
$71,000+	98,891	14.7
Median Household Income Missing	11,108	1.6
Race		
White	516,087	76.4
Black	82,847	12.3
Hispanic	33,479	5.0
Pacific Islander	7985	1.2
Native American	2994	.44
Other	11,221	1.7
Race Missing	21,208	3.1

***Data source: 2016 National Inpatient Sample dataset; results of descriptive statistic**
**** missing data was dropped**
*****no missing data**

Table 4. Sociodemographic and Clinical Characteristics (continued.) *

Variables	Unweighted (N)	Weighted (%)
Hospital Bed size* **		
Small	131,980	19.6
Medium	202,058	29.9
Large	340,750	50.5
Hospital Region* **		
Northeast	121,043	17.9
Midwest	170,996	25.4
South	274,101	40.6
West	108,648	16.1
Length of Stay**		
0-3 days	280,710	41.6
4+ days	394,065	58.4
Hospital Division* **		
New England	34,075	5.1
Middle Atlantic	86,962	12.9
East North Central	126,283	18.7
West North Central	44,712	6.6
South Atlantic	150,459	22.3
East South Central	57,754	8.5
West South Central	65,887	9.8
Mountain	34,900	5.2
Pacific	73,743	10.9
Comorbidities (Present)* **		
Congestive Heart Failure	273,692	40.6
Cardiac Arrhythmias	244,437	36.2
Valvular Disease	75,593	11.2
Pulmonary Circulation Disorders	77,758	11.5
Peripheral Vascular Disorders	108,081	16.0
Hypertension, Uncomplicated	326,452	48.3
Paralysis	12,965	1.9
Other Neurological Disorders	98,873	14.7
Diabetes, Uncomplicated	133,243	19.8
Diabetes, Complicated	121,557	18.0
Hypothyroidism	113,554	16.8
Renal Failure	184,969	27.4
Liver Disease	44,180	6.6
Peptic Ulcer Disease Excluding Bleeding	8,349	1.2
AIDS/HIV	2,548	0.4
Lymphoma	6,643	1.0
Metastatic Cancer	27,184	4.0
Solid Tumor Without Metastasis	53,401	7.9
Rheumatoid Arthritis/ Collagen Vascular	29,098	4.3
Coagulopathy	52,975	7.9
Obesity	122,620	18.2
Weight Loss	68,715	10.2
Fluid and Electrolyte Disorders	270,182	40.0
Blood Loss Anemia	9,126	1.4
Deficiency Anemia	37,526	5.6
Alcohol Abuse	51,710	7.7
Drug Abuse	40,261	6.0
Psychoses	22,520	3.3
Depression	123,544	18.3
Hypertension, Complicated	192,496	28.5

***Data source: 2016 National Inpatient Sample dataset; results of descriptive statistic**
**** missing data was dropped**
*****no missing data**

Table 5 presents the bivariate associations of inpatient mortality (n=27,057) with patient and hospital characteristics stratified by nonmetropolitan and metropolitan area. Mortality was highest in patients 75+ for patients from nonmetropolitan and metropolitan areas. Male patients

had a higher mortality rate. Patients from nonmetropolitan and metropolitan areas admitted to large hospitals in the Pacific hospital Division had higher mortality than those in other hospital divisions. The highest inpatient mortality was seen in nonmetropolitan patients with a length of stay between 0-3 days. Inpatient mortality was also higher in patients who presented with certain comorbidities. Comorbid conditions such as paralysis, other neurologic disorders, liver disease, metastatic cancer, solid tumor without metastasis, and weight loss had the largest association with mortality.

Table 5. Bivariate Association of Inpatient Mortality with Selected Characteristics Stratified by Nonmetropolitan/Metropolitan Residence.

Variable	Nonmetropolitan	p-value	Metropolitan	p-value
Age Group (Years of Age)*		p=0.00		p=0.00
40-54	328 (2.01%)		1,094 (1.70%)	
55-64	969 (3.16%)		3,588 (2.91%)	
65-74	1,613 (4.14%)		5,885 (3.93%)	
75+	2,564 (5.50%)		10,883 (5.31%)	
Sex*		p=0.00		p=0.00
Male	2,888 (4.37%)		11,150 (4.31%)	
Female	2,586 (3.89%)		10,300 (3.63%)	
Insurance Type*		p=0.00		p=0.00
Medicare	4,227 (4.32%)		16,613 (4.20%)	
Medicaid	397 (2.77%)		1,585 (2.48%)	
Private including HMO	528 (3.83%)		2,337 (3.84%)	
Self-Pay	100 (3.72%)		291 (2.97%)	
No Charge	6 (3.16%)		19 (1.85%)	
Other	216 (5.91%)		605 (5.46%)	
Median Household Income		p=0.01		p=0.00
$1-$42,999	2,931 (4.12%)		5,942 (3.64%)	
$43,000-$53,999	1,833 (4.22%)		5,416 (3.91%)	
$54,000-$70,999	487 (4.12%)		5,444 (3.98%)	
$71,000+	63 (4.95%)		4,404 (4.51%)	
Median Household Income Missing	160 (3.26%)		244 (3.94%)	
Race		p=0.03		p=0.00
White	4,605 (4.10%)		16,157 (4.01%)	
Black	276 (3.55%)		2,416 (3.23%)	
Hispanic	110 (4.27%)		1,230 (3.99%)	
Asian or Pacific Islander	11 (2.28%)		453 (6.04%)	
Native American	54 (3.95%)		56 (3.45%)	
Other	63 (4.96%)		446 (4.49%)	
Race Missing	355 (5.30%)		692 (4.81%)	
Hospital Bed Size**		p=0.00		p=0.00
Small	661 (3.34%)		3,793 (3.38%)	
Medium	1,174 (3.89%)		6,674 (3.88%)	
Large	3,639 (4.41%)		10,983 (4.25%)	
Hospital Region**		p=0.00		p=0.00
Northeast	593 (4.33%)		4,518 (4.21%)	
Midwest	1,704 (4.07%)		4,564 (3.53%)	
South	2,606 (4.01%)		7,827 (3.74%)	
West	573 (4.73%)		4,541 (4.70%)	
Length of Stay*		p=0.33		p=0.01
0-3 Days	2,473 (4.19%)		8,584 (3.87%)	
4+ Days	3,001 (4.08%)		12,866 (4.01%)	
Hospital Division**		p=0.00		p=0.00
New England	231 (4.44%)		1,067 (3.69%)	
Middle Atlantic	363 (4.26%)		3,455 (4.40%)	
East North Central	980 (3.72%)		3,477 (3.47%)	
West North Central	726 (4.67%)		1,093 (3.74%)	
South Atlantic	944 (3.68%)		4,582 (3.66%)	
East South Central	1,007 (4.28%)		1,375 (3.97%)	
West South Central	666 (4.15%)		1,894 (3.79%)	
Mountain	261 (4.61%)		1,149 (3.92%)	
Pacific	311 (4.83%)		3,397 (5.04%)	

***missing data was dropped**
****no missing data**
*****Omitted due to collinearity**

Table 5. Bivariate Association of Inpatient Mortality with Selected Characteristics Stratified by Nonmetropolitan/Metropolitan Residence (continued.)

Comorbid Condition	Nonmetropolitan	p-value	Metropolitan	p-value
Congestive Heart Failure**		p=0.00		p=0.00
Absent	2,761 (3.44%)		10,635 (3.31%)	
Present	2,713 (5.18%)		10,815 (4.89%)	
Cardiac Arrhythmias**		p=0.00		p=0.00
Absent	2,760 (3.20%)		10,305 (2.99%)	
Present	2,714 (5.85%)		11,145 (5.63%)	
Valvular Disease**		p=0.00		p=0.00
Absent	4,837 (4.05%)		18,670 (3.89%)	
Present	637 (4.86%)		2,780 (4.45%)	
Pulmonary Circulation Disorders**		p=0.00		p=0.00
Absent	4,641 (3.89%)		17,876 (3.74%)	
Present	883 (6.32%)		3,574 (5.53%)	
Peripheral Vascular Disorders**		p=0.00		p=0.00
Absent	4,505 (3.99%)		17,425 (3.84%)	
Present	969 (4.94%)		4,025 (4.55%)	
Hypertension, Uncomplicated**		p=0.00		p=0.00
Absent	3,300 (4.87%)		13,333 (4.75%)	
Present	2,174 (3.35%)		8,117 (3.10%)	
Paralysis**		p=0.00		p=0.00
Absent	5,269 (4.06%)		20,717 (3.90%)	
Present	205 (7.87%)		733 (7.07%)	
Other Neurological Disorders**		p=0.00		p=0.00
Absent	3,866 (3.38%)		14,503 (3.14%)	
Present	1,628 (8.93%)		6,947 (8.59%)	
Chronic Pulmonary Disease***				
Diabetes, Uncomplicated**		p=0.01		p=0.00
Absent	4,410 (4.21%)		17,767 (4.07%)	
Present	1,064 (8.93%)		3,683 (3.49%)	
Diabetes, Complicated**		p=0.00		p=0.00
Absent	4,698 (4.26%)		17,963 (4.06%)	
Present	776 (3.50%)		3,487 (3.51%)	
Hypothyroidism**		p=0.02		p=0.00
Absent	4,642 (4.19%)		18,028 (4.00%)	
Present	832 (3.84%)		3,422 (3.72%)	
Renal Failure**		p=0.00		p=0.00
Absent	3,766 (3.81%)		13,971 (3.57%)	
Present	1,708 (5.08%)		7,479 (4.94%)	
Liver Disease**		p=0.00		p=0.00
Absent	4,764 (3.82%)		18,548 (3.67%)	
Present	710 (9.18%)		2,902 (7.96%)	
Peptic Ulcer Disease**		p=0.01		p=0.00
Absent	5,430 (4.14%)		21,268 (3.97%)	
Present	44 (2.86%)		182 (2.67%)	
AIDS/HIV**		p=0.94		p=0.83
Absent	5,466 (4.13%)		21,355 (3.96%)	
Present	8 (4.02%)		95 (4.04%)	
Lymphoma**		p=0.00		p=0.00
Absent	5,399 (4.11%)		21,090 (3.93%)	
Present	75 (6.74%)		360 (6.51%)	
Metastatic Cancer**		p=0.00		p=0.00
Absent	4,956 (3.89%)		19,103 (3.67%)	
Present	518 (10.29%)		2,347 (10.60%)	

***missing data was dropped**
****no missing data**
*****Omitted due to collinearity**

Table 5. Bivariate Association of Inpatient Mortality with Selected Characteristics Stratified by Nonmetropolitan/Metropolitan Residence (continued.)

Comorbid Condition	Nonmetropolitan	p-value	Metropolitan	p-value
Solid Tumor without Metastasis**		p=0.00		p=0.00
Absent	4,596 (3.75%)		17,778 (3.56%)	
Present	878 (8.66%)		3,672 (8.49%)	
Rheumatoid Arthritis/Collagen Vascular**		p=0.92		p=0.00
Absent	5,252 (4.13%)		20,604 (3.97%)	
Present	222 (4.10%)		846 (3.57%)	
Coagulopathy**		p=0.00		p=0.00
Absent	4,602 (3.73%)		17,512 (3.51%)	
Present	872 (9.57%)		3,938 (8.98%)	
Obesity**		p=0.00		p=0.00
Absent	4,844 (4.42%)		18,851 (4.26%)	
Present	630 (2.75%)		2,599 (2.61%)	
Weight Loss**		p=0.00		p=0.00
Absent	4,365 (3.64%)		16,691 (3.43%)	
Present	1,109 (8.68%)		4,759 (8.51%)	
Fluid and Electrolyte Disorders**		p=0.00		p=0.00
Absent	2,258 (2.77%)		7,715 (2.39%)	
Present	3,216 (6.31%)		13,735 (6.27%)	
Blood Loss Anemia**		p=0.81		p=0.55
Absent	5,418 (4.13%)		21,205 (3.96%)	
Present	71 (4.02%)		284 (3.82%)	
Deficiency Anemia**		p=0.00		p=0.00
Absent	5,250 (4.18%)		20,467 (4.00%)	
Present	224 (3.25%)		983 (3.21%)	
Alcohol Abuse**		p=0.46		p=0.00
Absent	5,108 (4.14%)		20,046 (4.01%)	
Present	366 (3.98%)		1,404 (3.30%)	
Drug Abuse**		p=0.00		p=0.00
Absent	5,362 (4.24%)		20,764 (4.09%)	
Present	112 (1.87%)		686 (2.00%)	
Psychosis**		p=0.00		p=0.00
Absent	5,406 (4.19%)		21,020 (4.02%)	
Present	68 (1.93%)		430 (2.26%)	
Depression**		p=0.00		p=0.00
Absent	4,845 (4.45%)		18,836 (4.26%)	
Present	629 (2.65%)		2,614 (2.62%)	
Hypertension, Complicated**		p=0.00		p=0.00
Absent	3,875 (3.92%)		14,114 (3.68%)	
Present	1,599 (4.74%)		7,336 (4.62%)	

***missing data was dropped**
****no missing data**
*****Omitted due to collinearity**

Table 6 presents unadjusted and adjusted models for factors related to inpatient mortality. Patients aged 75+ had an increased odds of mortality (adjusted OR: 3.36; 95% CI: 3.16-3.57). Patients in nonmetropolitan areas had increased odds of mortality than those in metropolitan areas (adjusted OR: 1.04; 95% CI: 1.01-1.08). Male patients had higher odds of mortality compared to female patients. Patients with Medicaid (adjusted OR: 1.04; 95% CI: 0.99-1.10), private (adjusted OR: 1.25; 95% CI: 1.20-1.30), self-pay (adjusted OR: 1.28; 95% CI: 1.15-1.42), and Worker's Compensation, CHAMPUS, or CHAMPVA (adjusted OR: 1.63; 95% CI:

1.51-1.75) had increased odds of mortality than those receiving Medicare. Patients in large hospitals had higher odds of mortality than those in small hospitals (adjusted OR: 1.30; 95% CI: 1.25-1.34). Patients in hospitals located in the Middle Atlantic, East South Central and Pacific Hospital Divisions had higher odds of mortality than those in hospitals in New England Division (adjusted OR: 1.12; 95% CI: 1.05-1.20, adjusted OR: 1.11; 95% CI: 1.04-1.19, adjusted OR: 1.26; 95% CI: 1.18-1.35, respectively).

Table 6. Unadjusted and Adjusted Odds Ratios for Specific Variables Related to Mortality

Characteristics	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age Groups (Year)**		
40-54	REF	REF
55-64	1.70 (1.60-1.81)	1.68 (1.58-1.79)
65-74	2.31 (2.17-2.45)	2.41 (2.27-2.57)
75+	3.15 (2.96-3.34)	3.36 (3.16-3.57)
Sex**		
Female	REF	REF
Male	1.18 (1.16-1.21)	1.18 (1.15-1.21)
Length of Stay**		
0-3 days	REF	REF
4+ days	1.02 (0.99-1.05)	0.99 (0.97-1.02)
Insurance Type**		
Medicare	REF	REF
Medicaid	0.59 (0.56-0.62)	1.04 (0.99-1.10)
Private	0.90 (0.86-0.95)	1.25 (1.20-1.30)
Self-Pay	0.73 (0.66-0.82)	1.28 (1.15-1.42)
No Charge	0.48 (0.31-0.73)	0.92 (0.62-1.37)
Other*	1.34 (1.16-1.54)	1.63 (1.51-1.75)
Median Household Income		
$ 1-$42,999	0.83 (0.80-0.87)	0.98 (0.94-1.02)
$43,000-$53,999	0.88 (0.84-0.92)	0.98 (0.94-1.02)
$54,000-$70,999	0.88 (0.84-0.92)	0.95 (0.91-0.98)
$71,000+	REF	REF
Median Household Income Missing	0.80 (0.71-0.89)	0.90 (0.81-1.00)
Hospital Bed Size***		
Small	REF	REF
Medium	1.16 (1.10-1.22)	1.16 (1.12-1.20)
Large	1.29 (1.22-1.35)	1.30 (1.25-1.34)
Nonmetropolitan	1.05 (1.01-1.09)	1.04 (1.01-1.08)
Metropolitan	REF	REF
Race		
White	REF	REF
Black	0.80 (0.77-0.87)	0.93 (0.89-0.97)
Hispanic	0.99 (0.93-1.06)	0.97 (0.91-1.03)
Asian or Pacific Islander	1.47 (1.33-1.62)	1.14 (1.03-1.26)
Native American	0.91 (0.72-1.14)	0.99 (0.81-1.19)
Other	1.13 (1.00-1.28)	1.09 (1.00-1.20)
Race Missing	1.25 (1.15-1.35)	1.30 (1.21-1.39)
Hospital Division***		
New England	REF	REF
Middle Atlantic	1.16 (1.04-1.29)	1.12 (1.05-1.20)
East North Central	0.92 (0.83-1.03)	0.92 (0.86-0.98)
West North Central	1.07 (0.95-1.21)	0.99 (0.92-1.07)
South Atlantic	0.96 (0.87-1.07)	0.94 (0.88-1.00)
East South Central	1.08 (0.97-1.21)	1.11 (1.04-1.19)
West South Central	1.02 (0.92-1.14)	1.01 (0.95-1.09)
Mountain	1.06 (0.94-1.20)	0.98 (0.91-1.06)
Pacific	1.34 (1.20-1.49)	1.26 (1.18-1.35)

***Worker's Compensation, CHAMPUS, CHAMPVA, Title V, and other government programs**
****missing data was dropped**
*****no missing data**

Table 7 shows adjusted odds ratios for inpatient mortality stratified by metropolitan and nonmetropolitan areas. The p-values for the interaction results are shown in the last column. Among patients 75+, those in metropolitan areas had slightly higher odds of mortality compared to those in nonmetropolitan areas. Male patients had higher odds of mortality in metropolitan

areas (OR: 1.20; 95% CI: 1.17-1.23) and nonmetropolitan areas (OR: 1.10; 95% CI: 1.04-1.10). Patients with Medicaid also had slightly increased odds of mortality in nonmetropolitan (OR: 1.14; 95% CI: 1.01-1.29) and metropolitan areas (OR: 1.02; 95% CI: 0.96-1.08).

Table 7. Multiple Logistic Regression Analysis of Variables Stratified by Metropolitan/Nonmetropolitan Related to Mortality

Characteristics	Metropolitan Adjusted OR (95%CI)*	Nonmetropolitan Adjusted OR (95%CI)*	P-Value for Interaction Term**
Age Groups (Year)* **			
40-54	REF	REF	REF
55-64	1.70 (1.59-1.82)	1.62 (1.42-1.84)	0.21
65-74	2.44 (2.28-2.62)	2.32 (2.04-2.65)	0.10
75+	3.40 (3.18-3.64)	3.23 (2.83-3.68)	0.10
Sex* **			
Male	1.20 (1.17-1.23)	1.10 (1.04-1.16)	0.01
Female	REF	REF	REF
Length of Stay (Days)* **			
0-3	REF	REF	
4+	1.00 (0.97-1.03)	0.94 (0.89-0.99)	0.06
Insurance Type* **			
Medicare	REF	REF	REF
Medicaid	1.02 (0.96-1.08)	1.14 (1.01-1.29)	0.06
Private	1.26 (1.20-1.32)	1.21 (1.10-1.34)	0.50
Self-Pay	1.22 (1.08-1.38)	1.52 (1.23-1.87)	0.08
No Charge	0.82 (0.52-1.30)	1.51 (0.66-3.42)	0.23
Other	1.63 (1.50-1.78)	1.64 (1.42-1.89)	0.87
Median Household Income			
$1-$42,999	0.98 (0.94-1.03)	0.93 (0.72-1.21)	0.57
$43,000-$53,999	0.99 (0.95-1.03)	0.92 (0.71-1.19)	0.47
$54,000-$71,000	0.95 (0.91-0.99)	0.85 (0.65-1.12)	0.40
$ 71,000+	REF	REF	REF
Median Household Income		0.73 (0.54-0.99)	0.07
Missing	0.98 (0.86-1.12)		
Hospital Bed Size**			
Small	0.78 (0.75-0.81)	0.70 (0.65-.77)	0.62
Medium	0.90 (0.87-0.93)	0.85 (0.80-0.91)	0.13
Large	REF	REF	REF
Race			
White	REF	REF	REF
Black	0.93 (0.89-0.97)	0.95 (0.83-1.07)	0.87
Hispanic	0.96 (0.90-1.02)	1.08 (0.89-1.32)	0.28
Asian or Pacific Islander	1.18 (1.07-1.30)	0.44 (0.23-0.81)	0.00
Native American	0.96 (0.73-1.25)	1.00 (0.76-1.32)	0.75
Other	1.07 (0.97-1.18)	1.29 (1.00-1.67)	0.33
Race Missing	1.32 (1.21-1.43)	1.26 (1.12-1.42)	0.89
Hospital Division**			
New England	REF	REF	REF
Middle Atlantic	1.17 (1.08-1.25)	0.90 (0.76-1.06)	0.06
East North Central	0.95 (0.88-1.02)	0.78 (0.67-0.91)	0.17
West North Central	0.96 (0.88-1.05)	0.94 (0.81-1.10)	0.96
South Atlantic	0.97 (0.90-1.04)	0.77 (0.67-0.90)	0.12
East South Central	1.15 (1.06-1.25)	0.94 (0.81-1.04)	0.23
West South Central	1.04 (0.96-1.12)	0.89 (0.76-1.04)	0.29
Mountain	0.99 (0.90-1.08)	0.92 (0.77-1.11)	0.76
Pacific	1.30 (1.21-1.40)	1.06 (0.89-1.27)	0.10

***Odds ratios adjusted for all variables**
****P-value for interaction was obtained by including the interaction term for nonmetropolitan variable separately with each variable**
*****missing data was dropped**
******no missing data**

Table 8 shows results of the multiple logistic regression of inpatient mortality and comorbidities stratified by metropolitan and nonmetropolitan areas. The p-values for the interaction results are shown in the last column. Many of the comorbid conditions were positively associated with inpatient mortality without regard to differences between metropolitan and nonmetropolitan areas. I focus on the results in which the interaction effects were significant. Among patients with pulmonary circulation disorders, those in nonmetropolitan areas had increased odds of mortality compared to those in metropolitan areas (adjusted OR: 1.44; 95% CI: 1.33-1.56 vs. adjusted OR: 1.29; 95% CI 1.24-1.34). Among patients with COPD with fluid and electrolyte imbalance, those in metropolitan areas had increased odds of mortality compared to those in nonmetropolitan areas (adjusted OR: 2.19; 95% CI: 2.13-2.26 vs. adjusted OR: 1.93; 95% CI: 1.82-2.04). Among patients with COPD with metastatic cancer, those in metropolitan areas had increased odds of mortality compared to those in nonmetropolitan areas (adjusted OR: 1.82; 95% CI: 1.71-1.93 vs. adjusted OR: 1.59; 95% CI: 1.41-1.81).

Table 8. Multiple Logistic Regression Analysis of Comorbidities Stratified by Metropolitan/Nonmetropolitan Related to Mortality

Comorbidities****	Metropolitan Adjusted OR (95%CI)*	Nonmetropolitan Adjusted OR (95%CI)*	P-Value for Interaction Term**
Congestive Heart Failure	1.38 (1.34-1.43)	1.42 (1.33-1.51)	0.12
Cardiac Arrhythmia	1.72 (1.67-1.77)	1.69 (1.59-1.79)	0.73
Valvular Disease	0.88 (0.84-0.92)	0.93 (0.85-1.02)	0.05
Pulmonary Circulation Disorders	1.29 (1.24-1.34)	1.44 (1.33-1.56)	0.01
Peripheral Vascular Disorders	1.11 (1.07-1.15)	1.16 (1.07-1.24)	0.16
Hypertension, Uncomplicated	0.73 (0.70-0.75)	0.76 (0.71-0.82)	0.23
Paralysis	1.58 (1.46-1.71)	1.75 (1.50-2.04)	0.28
Other Neurologic Disorders	2.64 (2.56-2.72)	2.60 (2.44-2.77)	0.38
Chronic Pulmonary Disease* **			
Diabetes, Uncomplicated	0.92 (0.88-0.95)	0.97 (0.90-1.04)	0.11
Diabetes, Complicated	0.78 (0.75-0.82)	0.76 (0.70-0.83)	0.28
Hypothyroidism	0.91 (0.88-0.95)	0.90 (0.83-0.97)	0.67
Renal Failure	1.26 (1.20-1.33)	1.25 (1.13-1.39)	0.89
Liver Disease	2.19 (2.09-2.29)	2.35 (2.14-2.58)	0.17
Peptic Ulcer Disease Excluding Bleeding	0.63 (0.54-0.73)	0.67 (0.49-0.91)	0.67
AIDS/HIV	1.00 (0.81-1.24)	0.89 (0.42-1.89)	0.71
Lymphoma	1.42 (1.27-1.59)	1.46 (1.14-1.86)	0.94
Metastatic Cancer	1.82 (1.71-1.93)	1.59 (1.41-1.81)	0.04
Solid Tumor Without Metastasis	1.78 (1.69-1.87)	1.86 (1.68-2.05)	0.43
Rheumatoid Arthritis/Collagen Vascular	0.93 (0.87-1.00)	1.04 (0.90-1.19)	0.19
Coagulopathy	1.83 (1.76-1.90)	1.86 (1.71-2.01)	0.65
Obesity	0.70 (0.67-0.73)	0.67 (0.61-0.73)	0.62
Weight Loss	1.75 (1.68-1.81)	1.75 (1.63-1.89)	0.47
Fluid and Electrolyte Imbalance	2.19 (2.13-2.26)	1.93 (1.82-2.04)	0.00
Blood Loss Anemia	0.82 (0.72-0.92)	0.85 (0.66-1.08)	0.66
Deficiency Anemia	0.67 (0.63-0.72)	0.62 (0.54-0.72)	0.34
Alcohol Abuse	0.61 (0.57-0.64)	0.66 (0.59-0.75)	0.21
Drug Abuse	0.55 (0.51-0.59)	0.48 (0.39-0.58)	0.19
Psychosis	0.64 (0.58-0.71)	0.53 (0.41-0.68)	0.10
Depression	0.67 (0.64-0.70)	0.64 (0.59-0.70)	0.37
Hypertension, Complicated	0.73 (0.69-0.76)	0.74 (0.67-0.82)	0.88

***Odds ratios adjusted for all variable**
****P-value for interaction was obtained by including the interaction term for nonmetropolitan variable separately with each variable**
*****Omitted due to collinearity**
******No Missing Data**

2.3 Discussion

The first aim of this study was to assess whether patient and hospital characteristics were associated with increased odds of inpatient mortality in patients diagnosed with COPD. Patients who were 75+ had 3 times higher odds of inpatient mortality than patients who were 40-54 years old. These results are consistent with Patil et al. (2003) who used the 1996 NIS dataset and found a higher mortality rate in patients older than 65 years. I found that males with COPD had an 18% increase in odds of mortality compared to females. This result is consistent with that of Jinjuvadia et al. (2017) who found that males had a 14% increase in the odds of inpatient mortality compared to female using NIS data from 2002 to 2010. de Torres et al. (2009) found

slightly higher respiratory-related mortality in males as compared to females. Perez et al. (2020) used 5-year survival rates to determine a difference between males and females and reported that even though prevalence of COPD is increasing among females, 5-year survival rates are higher for females than males. Overall age-adjusted COPD mortality rates for males declined from 2009-2019 while mortality rates for females did not change significantly (Carlson et al., 2022). This trend warrants more research.

The type of insurance that patients held also had an association with inpatient mortality. Patients with Medicaid, private, Worker's Compensation, CHAMPUS, or CHAMPVA had higher odds of mortality than those with Medicare. The highest odds of mortality were seen in patients with Worker's Compensation, CHAMPUS, or CHAMPVA. The results of the present study are similar to Cheng et al. (2014) who found similar results when looking at in-hospital mortality in patients with COPD who had Worker's Compensation as compared to patients with COPD with Medicare. An earlier diagnosis of COPD would explain the increased odds of mortality in patients with Worker's Compensation or Medicaid. It would be beneficial to look at future years of data to see if this mortality trend is continuing.

Being admitted to a large hospital (at least 425 beds) was associated with an increase in the odds of inpatient mortality compared with being admitted to a small hospital (less than 50 beds). These results are similar to Jinjuvadia et al. (2017), who studied trends in in-hospital mortality and found that patients with COPD admitted to large teaching hospitals had higher odds of mortality compared to those admitted to non-teaching hospitals. Patients admitted to smaller hospitals and who need more intensive care are likely to be transferred to a larger facility for care, and this could be one of the reasons for the higher risk of mortality in patients with COPD who are in larger facilities.

Higher odds of inpatient mortality were also associated with hospital location. Patients admitted to hospitals in the in East South Central and Pacific Divisions had higher odds of mortality compared to patients admitted to hospitals in the New England Division. The East South Central Division includes the states of Kentucky, Tennessee, Mississippi, and Alabama. Sullivan et al. (2018) reported worse outcomes in patients with COPD in states in Appalachia, the Mississippi delta, and the South.

In the second aim, this study compared inpatient mortality among patients with COPD living in nonmetropolitan areas and those living in metropolitan areas. When stratifying for residence, among patients who were 75+, those who lived in metropolitan areas had a slightly higher odds of mortality compared to those who lived in nonmetropolitan areas. In contrast, Iyer et al. (2021) reported that mortality increased in all age groups specifically for patients 65 years or older living in rural areas. Johnston et al. (2019) found that lack of access to specialists in rural hospitals led to an increase in inpatient mortality. Most pulmonologists practice in urban areas, and rural patients have limited access to a pulmonologist (Croft et al., 2016). Male patients had higher odds of mortality as compared to female patients and the odds were higher in patients living in metropolitan areas. Celli et al. (2011) looked at all-cause mortality and found that men with COPD had higher odds of mortality as compared to women over a three-year period. It will be important to continue to assess mortality related to sex. With women being diagnosed at a higher rate a trend upward in mortality could also be seen.

The third aim of this study was to explore the effects of comorbid conditions on inpatient mortality and to examine whether these effects varied by residence. I found that odds of inpatient mortality differed by place of patient residence for metastatic cancer, pulmonary circulation disorders, and fluid and electrolyte imbalance. Divo et al. (2012) also found metastatic cancer in

patients with COPD to be a predictor of mortality. Roberts et al. (2011) found that patients with COPD with certain cancers and arrhythmias had increased odds of mortality. Although there was no difference by place of residence, I found that patients who had pulmonary circulation disorders had increased odds of mortality. Cavailles et al. (2013) discussed pulmonary artery remodeling that leads to the development of pulmonary hypertension in patients with COPD. I found that patients with liver disease had a two-fold increase in the odds of mortality for those living in metropolitan areas. Kotlyarov and Bulgakov (2021) determined that patients with COPD had an increased likelihood of developing fatty liver disease. Patients with COPD also have a significant number of comorbid conditions and having multiple comorbidities is associated with increased odds of mortality. Efficiently diagnosing all conditions and treating each appropriately will be a target of COPD management.

2.4 Strengths

The NIS dataset allows researchers access to a large sample of inpatient data. This allows for the examination of multiple patient conditions and also allows for various subgroup analyses. The NIS dataset also contains data from 47 states, which allows researchers to examine trends in many areas in the U.S. The focus of this paper was on COPD. COPD continues to be a leading cause of death and hospitalizations across the U.S. and the world. Gaps in healthcare for rural residents are well documented, especially in patients diagnosed with chronic conditions. The focus of the research study was to look for differences in mortality in patients with COPD in nonmetropolitan and metropolitan areas, an understudied area of research. It would be useful for researchers to use future waves of NIS data to further examine trends in inpatient mortality among patients in urban and rural areas.

2.5 Limitations

The NIS data include discharges from 47 states, limiting its generalizability. Miscoding and misdiagnosis can occur in hospital discharge data; however, HCUP data is quality checked and has a low percentage of missing data. Since NIS data is cross-sectional, I cannot track discharges across multiple years. HCUP data has limited clinical information, which does not allow researchers to control for many other factors that may be associated with health and inpatient mortality, including limitations in activities of daily living, self-reported health, social support, including marital status. HCUP data does not provide patient-level electronic medical records needed to provide a complete episode of care that could potentially lead to variables not identified in the study to lead to a readmission.

2.6 Conclusion

Patients with COPD who are older, male, those who live in the East, South Central, and Pacific Divisions, and those with certain comorbidities have higher odds of inpatient mortality. In contrast with previous studies, I found that patients living in nonmetropolitan areas had a slightly higher odds of mortality than those living in metropolitan areas. It would be useful for future research to examine factors associated with inpatient morality among patients with COPD living in urban and rural areas.

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ARTICLE 3: THE EFFECTS OF RURALITY ON COPD PATIENTS RELATED TO AVERAGE COST OF CARE

3.0 Introduction

Nearly 16 million people in the United States have been diagnosed with chronic obstructive pulmonary disease (COPD), the third-leading cause of death (Hess et al., 2021). An exacerbation, a common experience with COPD, is defined as seeking medical care for increased symptoms that require intensive medical management (Dalal et al., 2010).

Total cost of care for patients with COPD can be broken down into direct costs, such as medical and pharmacy costs (Dalal et al., 2010), and indirect costs, such as lost wages, missed workdays, and premature retirement due to illness (Wacker et al., 2016). Direct costs can be measured as attributable costs, such as hospitalizations, and excess costs, such as the extra cost of having COPD (Ehteshami-Afshar et al., 2016). The cost of care for COPD is affected by where patients receive their care (Jahnz-Rózyk et al., 2009). Direct health care expenditures related to COPD have been reported to be as high as $29.5 billion dollars annually (American Lung Association, n.d.). A study conducted using the National Inpatient Sample (NIS) data from 2002-2010 found that hospitalization costs increased by nearly $16,000 per admission over the eight-year span (Jinjuvadia et al., 2017).

A determining factor related to cost for patients diagnosed with COPD is exacerbations leading to readmissions (Villegas et al., 2021). Fortis et al. (2023) found that when adjusting for travel time to a Veteran's Affairs Medical Center, patients with COPD who lived in isolated rural areas had more frequent readmissions. Sridhara and Acharya (2021) determined that patients with COPD who also had multiple comorbidities had an increased likelihood of readmission compared to patients with COPD with no comorbidities. Patients with COPD who have a

household income in the lowest quartile have higher readmission rates than those in the highest quartile (Prieto-Centurion et al., 2013). Kirsch et al. (2019) found that patients with comorbidities had higher costs of care compared to patients without comorbidities.

The aims of this study were to 1) identify factors related to increased costs of COPD hospitalizations; 2) examine differences in hospital costs among patients living in nonmetropolitan areas and those living in metropolitan areas; and 3) explore the effects of comorbid conditions on costs and whether these effects vary by nonmetropolitan and metropolitan areas.

3.1 Methods

3.1.1 Data Source

Data were from the 2016 Nationwide Readmissions Database (NRD) developed by the Healthcare Cost and Utilization Project (HCUP); these data were the most recent available at the time of analysis. NRD represents 28 states and includes about 18 million annual discharges. The database has more than 100 clinical and non-clinical variables for each hospital stay. Hospital discharges were identified by state-specific linkage numbers and cannot be tracked across states (HCUP, n.d.a). These data include summary information from hospital discharges. NRD allows researchers to analyze national readmission rates for patients and their length of stay (HCUP, n.d.a).

3.1.2 Study Population

Most patients with COPD are diagnosed after the age of 40 (Collison et al., 2018; Mannino et al., 2015; Schell et al., 2012). Thus, I included all patients aged 40 and older with the International Classification of Disease, 10th Revision, Clinical Modification (ICD-10-CM) codes for acute exacerbation of COPD (AECOPD) in the analysis. Inclusion criteria were a

diagnosis of COPD using the following ICD-10 codes: J40, J410, J411, J418, J42, J430, J431, J432, J438, J439, J440, J441, and J449 (Mulpuru et al., 2017). Patients were excluded if: 1) they had a missing identification number or a missing length of stay; 2) their hospitalizations led to a transfer to another acute care hospital, 3) they died during the index hospitalization, which is the first admission for COPD in that calendar year; 4) the discharge month was December due to the possibility of discharge in the next calendar year; or 5) the patient was transferred to another short-term care facility or the patient left against medical advice. Patients were also excluded if they had missing information regarding their residence (see Figure 5).

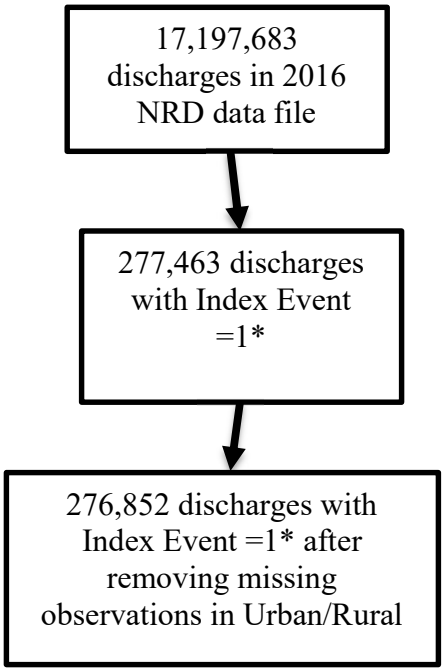

Figure 5. Study Flow Chart Diagram

***Index Event-Patient has a diagnosis using ICD 10 codes from J40 through J449. The patient's age is greater than or equal to 40. The patient was discharged between January and November. The patient had a discharge status of routine, transfer to other facility, was discharged on home health care, or discharged alive but the destination unknown. The patient also had to maintain residence in the same state for one year.**

3.1.3 Outcome Measure

The outcome of interest was the mean total hospital cost for index admissions. An index admission was classified as any hospitalization with a diagnosis of COPD that did not result in the patient's death between the months of January and November (Jiang et al., 2018). Index admissions were excluded if they occurred in December due to the possibility of discharge during the following calendar year. Since patients cannot be tracked over multiple years, patients discharged after 2016 would not be captured. Index hospitalization and readmission costs were determined for each patient using hospital-specific cost-to-charge ratios to convert total charges to estimated total hospital costs (Goel et al., 2020). HCUP provides a Cost-to-Charge file to estimate resource use cost during an inpatient hospital stay (HCUP, n.d.c). Calculated average total cost change over time data was adjusted for inflation (Karsy et al., 2019). The readmit variable was identified by defining patients who had an index admission and a subsequent readmission between 0 to 30 days.

3.1.4 Covariates

Predictor variables were classified as demographics, preexisting comorbidities, and clinical and hospital characteristics. Demographic and socioeconomic status variables were age, sex, insurance status, household income, length of stay, and comorbidities. Age was stratified into the following groups: 40-54 years, 55-64, 65-74, and 75 or older. Insurance status was categorized as Medicare, Medicaid, private insurance, other, and self-pay. Length of stay was categorized as 0-3 days and 4+ days. Household income was grouped as $1-$42,999, $43,000-$53,999, $54,000-$70,999, and $71,000 or greater. The AHRQ provides Elixhauser Comorbidities software to identify major comorbidities for risk adjustment. This software creates 31 binary variables based on ICD-9 and ICD-10 codes (Quan et al., 2005). Comorbidities were

then broken into four nonoverlapping quartiles. For variables for which more than 0.1% were missing, I created dummy variables representing missingness. For variables with less than 0.1% missing data points, I eliminated the patients from the analysis.

3.1.5 Nonmetropolitan and Metropolitan Variables

The urban-rural designation of the hospital is based on the county as identified by the American Hospital Association (HCUP, n.d.a). Rurality was defined using a census-level approximation of the rural-urban commuting area (RUCA) codes. The National Center for Health Statistics has developed a six-level scheme that helps define what is considered urban versus rural categories (https://www.cdc.gov/nchs/data_access/urban_rural.htm). The variable nonmetropolitan was created using the variable PL_NCHS (patient location: NCHS Urban-Rural Code) and using the values "5," which is micropolitan counties and the value "6," which is not-metropolitan and micropolitan counties. The variable metropolitan was created using the variable PL_NCHS and using the values "1" "Central" counties of metro areas of ≥ 1 million population, "2" "Fringe" counties of metro areas of ≥ 1 million population, "3" Counties in metro areas of 250,000-999,999 population, and "4" counties in metro areas of 50,000-249,000 population (HCUP, n.d.a; Ingram & Franco, 2014). I then created a variable labeled nonmetropolitan by using nonmetropolitan equals 1, and the variable metropolitan was created by using nonmetropolitan equals 0. I defined nonmetropolitan as rural and metropolitan as urban.

3.1.6 Statistical Analysis

Descriptive statistics were reported as numbers (%) for categorical variables (Table 9). The generalized linear model (GLM) with family gamma, log link was used for the adjusted analysis of total average cost and then used the margins command to determine differences in total average cost (Table 10). The generalized linear model (GLM) with family gamma, log link

was used for the adjusted analysis of total average costs in patients who had been readmitted in 30 days. I then used the margins command to determine differences in total average cost (Table 11). GLMs are appropriate for estimating healthcare costs because they can predict highly skewed outcomes. The implementation of a GLM requires the choice of a link function and a distribution family because they allow the expectation of the outcome to be a non-linear function (known as the link function) of the linear index of covariates and allow the variance to be a function of the expectation through a distribution family.

In adjusted models, the following variables were included as controls: age groups, sex, insurance type, median household income, length of stay, and the total number of comorbid conditions divided into four quartiles. Costs related to readmission were determined by creating a variable that only included costs of admission for patients who had a readmission. Costs related to readmission were then examined by selecting those patients who had a hospital readmission within 30 days.

The variable nonmetropolitan was used as an interaction variable to determine if the location of residence modified the association of mean total costs with age (40-54, 55-64, 65-74, and 75 or over), sex (male and female), primary payer (Medicare, Medicaid, Private, Self-Pay, and Other), length of stay (0-3 days and 4+ days), and the number of comorbidities (in quartiles). I used the Stata post-estimation margins command to generate the mean cost. Trend analysis was performed using Stata's *nptrend* command. All analyses were performed using Stata 16.1, and significance levels were set at less than 0.05. The Office of Research Compliance determined that this analysis did not require Institutional Review Board review.

3.2 Results

Table 9 shows demographic information, unweighted totals, and weighted percentages of the categorical data. The mean total hospital costs for patients with COPD were $11,841 (standard deviation, SD=$15,502). Mean total hospital costs for patients living in nonmetropolitan and metropolitan areas were $11,632 (SD=$14,854) and $11,886 (SD=$15,614), respectively. The mean age was 68.5 years (SD =11.6); the average length of stay was 4.3 days (SD=4.1). About 58% were female; 21% of patients lived in a nonmetropolitan area. About 61% were 65 years or older. More than 70% were enrolled in Medicare, and about 38% had a household income of less than $43,000. Fourteen percent of patients with COPD had between 6 and 14 comorbid conditions.

Table 9. Sociodemographic and Clinical Characteristics*

Characteristics	Unweighted (N)	Weighted (%)
Age (Yrs.)		
Mean (SD)	68.5 (11.6)	
Average Total Cost of Admission		
Mean (SD)	$11,841 ($15,502)	
Median	$8360	
Average Total Cost with Subsequent Readmission in 30 Days		
Mean (SD)	$16,918 ($23,905)	
Median	$10,530	
LOS (Days		
Mean (SD)	4.3 (4.1)	4.2 (0.1)
Median	3	
Readmission Rate	20%	
Variables	**Unweighted (N)**	**Weighted (%)**
Age Groups (Years)**		
40-54	34,683	12.9
55-64	72,416	26.5
65-74	81,012	29.2
75+	88,741	31.4
Sex***		
Male	116,347	41.9
Female	160,505	58.1
Length of Stay (Days)***		
0-3	146,091	53.6
4+	130,452	46.4
Insurance type**		
Medicare	195,211	70.8
Medicaid	38,975	13.7
Private	28,717	10.4
Self-pay	6,335	2.4
No charge	1,079	0.4
Other (Worker's Compensation, VA, Indian Health Services	6,226	2.2
Metropolitan-Nonmetropolitan***		
Metropolitan	229,075	78.9
Nonmetropolitan	47,777	21.1
Median Household Income Quartile		
$1 - $42,999	100,326	38.1
$43,000 - $53,999	74,731	27.5
$54,000 - $70,999	59,161	20.7
$71,000+	38,717	12.4
Median Household Income Missing	3,608	1.3
Comorbid Condition Quartiles (Number of Comorbidities)***		
1. (0-2)	105,416	38.6
2. (3)	54,605	19.7
3. (4-5)	78,000	27.9
4. (6-14)	38,522	13.8

***Data source: 2016 Nationwide Readmission Database; results of descriptive statistic**
**** missing data was dropped**
*****no missing data**

Table 10 presents the mean total hospital costs for patients with COPD from nonmetropolitan and metropolitan areas. The p-values for the interaction results are shown in the last column. Patients who lived in nonmetropolitan areas and had a length of stay of 4+ days had higher average costs than those who lived in nonmetropolitan areas and had a length of stay of 0-3 days (i.e., $16,578 vs. $9,214). There was also a significant difference between patients from metropolitan areas with a length of stay of 0-3 days and 4+ days (i.e., $8,108 vs. $15,400). The

mean total cost for both patients with a length of stay of both 0-3 days and 4+ days was higher in nonmetropolitan patients compared to metropolitan patients.

Household income also had an impact on average total cost. The average total costs for patients from nonmetropolitan areas with a household income of $71,000+ was higher than those living in nonmetropolitan with a household income of $1-$42,999 ($18,050 vs.$11,666). The average total costs for patients living in metropolitan areas was also higher in those with an income of $71,000+ compared to those with an income of $1-$42,999 ($13,603 vs. $10,935). The overall mean total cost for all categories of household income was also higher in patients who lived in nonmetropolitan areas compared to patients living in metropolitan areas.

In patients from nonmetropolitan areas with 4-5 comorbid conditions, the average total cost was higher than those from nonmetropolitan areas with 0-2 comorbid conditions ($13,249 vs. $10,709). The results were consistent with patterns observed for metropolitan areas ($12,518 vs. $9,475). When assessing the difference between nonmetropolitan and metropolitan patients, nonmetropolitan patients had a higher mean total cost related to a higher length of stay, having a household income in any one of the four quartiles, and for patients with COPD who had 4-5 comorbid conditions.

Table 10. Total Hospital Cost Stratified by Metropolitan/Nonmetropolitan

Characteristics	Metropolitan ($) (95% CI)	Nonmetropolitan ($) (95% CI)	P-Value for Interaction Term*
Age Group (Years)**			
40-54	11,237 (11,084-11,389)	12,477 (12,124-12,831)	REF
55-64	11,934 (11,822-12,046)	12,978 (12,724-13,231)	0.27
65-74	12,063 (11,960-12,166)	13,299 (13,065-13,533)	0.69
75+	11,220 (11,128-11,313)	12,739 (12,515-12,964)	0.22
Sex***			
Female	11,420 (11,353-11,488)	12,727 (12,559-12,895)	REF
Male	11,977 (11,383-12,061)	13,219 (13,020-13,417)	0.38
Length of Stay (Days)***			
0-3	8,108 (8,057-8,159)	9,213 (9,092-9,334)	REF
4+	15,400 (15,302-15,498)	16,578 (16,332-16,824)	0.00
Insurance type**			
Medicare	11,531 (11,465-11,596)	12,883 (12,731-13,0352)	REF
Medicaid	12,592 (12,431-12,753)	12,845 (12,451-13,239)	0.00
Private	11,656 (11,489-11,824)	13,121 (12,729-13,513)	0.67
Self-pay	10,227 (9,921-10,532)	11,673 (10,945-12,400)	0.55
No charge	10,745 (10,031-11,459)	11,647 (8,832-14,461)	0.81
Other (Worker's Compensation, VA, Indian Health Services)	11,200 (10,860-11,541)	13,350 (12,609-14,091)	0.05
Median Household Income			
$1 - $42,999	10,935 (10,848-11,022)	11,656 (11,506-11,805)	0.00
$43,000 - $53,999	11,180 (11,082-11,277)	13,158 (12,929-13,386)	0.02
$54,000 - $70,999	12,151 (12,040-12,262)	13,541 (13,091-13,990)	0.00
$71,000+	13,603 (13,454-13,752)	18,050 (16,344-19,756)	REF
Median Household Income Missing	12,025 (11,535-12,516)	12,819 (11,943-13,695)	0.00
Comorbid Condition Quartiles (Number of Comorbidities)***			
1. (0-2)	9,475 (9,404-9,545)	10,709 (10,550-10,869)	REF
2. (3)	10,702 (10,596-10,809)	11,904 (11,644-12,164)	0.27
3. (4-5)	12,518 (12,415-12,622)	13,249 (12,994-13,504)	0.00
4. (6-14)	16,498 (16,306-16,690)	18,934 (18,381-19,487)	0.40

*** P-value for interaction was obtained by including the interaction term for nonmetropolitan variable separately with each variable**
**** missing data was dropped**
*****no missing data**

Table 11 presents the mean total hospital costs for nonmetropolitan and metropolitan patients with COPD who had a readmission in 30 days. The p-values for the interaction results are shown in the last column. A length of stay of 4+ days in patients with COPD who were readmitted within 30 days had the largest impact on differences in mean total costs. Readmitted patients who lived in nonmetropolitan areas and had an original length of stay of 4+ days had higher costs than readmitted patients with COPD who lived in nonmetropolitan areas and had an original length of stay of 0-3 days ($19,818 vs. $17,968). There was also a significant difference between readmitted patients with COPD from metropolitan areas with an original length of stay of 0-3 days and those with an original stay of 4+ days ($14,847 vs. $18,030). Nonmetropolitan

patients with COPD had higher mean total costs as compared to metropolitan patients with COPD for both categories of length of stay.

In readmitted patients from nonmetropolitan (metropolitan) areas who had 6-14 comorbid conditions, the average total cost was higher than those who had 0-2 comorbid conditions ($30,072 vs. $13,698; $23,552 vs. $12,005 respectively). Nonmetropolitan patients with COPD also had a significantly higher cost as compared to metropolitan patients. These results show that having more comorbidities is associated with substantially higher costs. When considering whether a patient had a readmission in 30 days, length of stay and the number of comorbidities were associated with significantly different costs for patients living in nonmetropolitan areas versus patients in metropolitan areas.

Table 11. Margins Stratified by Metropolitan/Nonmetropolitan for Readmitted Patients Related to Total Hospital Cost

Characteristics	Metropolitan ($) (95% CI)	Nonmetropolitan ($) (95% CI)	P-Value for Interaction Term*
Age Group (Years)**			
40-54	15,176 (14,648-15,705)	18,947 (17,388-20,505)	REF
55-64	16,627 (16,234-17,019)	19,282 (18,223-20,342)	0.17
65-74	17,705 (17,313-18,096)	19,660 (18,716-20,604)	0.02
75+	15,999 (15,655-16,342)	18,580 (17,685-19,476)	0.16
Sex***			
Female	16,369 (16,113-16,625)	19,048 (18,334-19,761)	REF
Male	16,804 (16,512-17,097)	19,214 (18,440-19,989)	0.56
Length of Stay (Days)***			
0-3	14,847 (14,592-15,102)	17,968 (17,277-18,658)	REF
4+	18,030 (17,747-18,314)	19,818 (19,048-20,589)	0.00
Insurance type**			
Medicare	16,932 (16,158-16,626)	18,932 (18,330-19,533)	REF
Medicaid	17,036 (16,505-17,566)	18,843 (17,264-20,422)	0.36
Private	17,844 (17,086-18,602)	21,204 (19,129-23,279)	0.61
Self-pay	14,017 (12,729-15,305)	15,671 (12,217-19,125)	0.79
No charge	15,009 (12,030-17,987)	14,908 (-11,180-40,995)	0.87
Other (Worker's Compensation, VA, Indian Health Services)	16,332 (15,023-17,641)	20,567 (17,599-23,715)	0.30
Median Household Income			
$1 - $42,999	15,303 (14,997-15,608)	17,666 (17,043-18,289)	0.56
$43,000 - $53,999	15,932 (15,573-16,292)	18,798 (17,897-19,699)	0.67
$54,000 - $70,999	17,429 (17,009-17,848)	18,378 (16,595-20,160)	0.24
$71,000+	19,810 (19,237-20,383)	24,772 (18,272-31,273)	REF
Median Household Income Missing	17,191 (15,357-19,026)	19,368 (15,300-23,435)	0.56
Comorbid Condition Quartiles (Number of Comorbidities)***			
1. (0-2)	12,005 (11,738-12,273)	13,698 (13,040-14,357)	REF
2. (3)	14,053 (13,676-14,429)	16,054 (15,076-17,032)	0.98
3. (4-5)	17,075 (16,736-17,414)	18,829 (17,906-19,753)	0.37
4. (6-14)	23,552 (22,974-24,130)	30,072 (28,174-31,970)	0.01

*** P-value for interaction was obtained by including the interaction term for nonmetropolitan variable separately with each variable**
**** missing data was dropped**
*****no missing data**

Table 12 shows the mean total costs for patients diagnosed with COPD, focusing on comorbidities. The p-values for the interaction results are shown in the last column. I focused on the results in which the interaction effects were significant. Patients with congestive heart failure had higher mean total costs if they lived in a nonmetropolitan area compared to those living in metropolitan areas ($14,392 vs. $13,580). Among patients with uncomplicated hypertension, those from nonmetropolitan areas had higher mean total costs compared to those from metropolitan areas ($12,526 vs. $11,377). In patients with coagulopathy, those from nonmetropolitan areas had higher mean total costs than those from metropolitan areas ($21,292 vs. $17,572). Among patients with fluid and electrolyte imbalance, those who lived in a

nonmetropolitan area had higher mean total costs than those from metropolitan areas ($15,052 vs. $14,392). This was also the case for patients with depression ($13,265 vs. $11,966). Among patients with metastatic cancer, those from metropolitan areas had higher mean total costs than those from nonmetropolitan areas ($15,918 vs. $14,996).

Table 12. Margins Stratified by Metropolitan/Nonmetropolitan for Comorbidities Related to Total Hospital Cost

Comorbidities (Present)	Metropolitan ($) (95% CI)	Nonmetropolitan ($) (95% CI)	P-Value for Interaction Term*
Congestive Heart Failure**	13,580 (13,458-13,702)	14,392 (14,107-14,678)	0.02
Cardiac Arrhythmia**	13,640 (13,512-13,767)	15,026 (14,708-15,344)	0.06
Valvular Disease**	13,445 (13,197-13,694)	14,856 (14,183-15,528)	0.36
Pulmonary Circulation Disorders**	15,172 (14,932-15,413)	16,979 (16,305-17,654)	0.13
Peripheral Vascular Disorders**	12,848 (12,648-13,048)	13,862 (13,367-14,356)	0.95
Hypertension, Uncomplicated**	11,377 (11,299-11,454)	12,526 (12,336-12,717)	0.00
Hypertension, Complicated**	13,245 (13,088-13,402)	14,327 (13,922-14,732)	0.85
Paralysis**	23,412 (21,605-25,219)	26,206 (21,667-30,744)	0.70
Other Neurologic Disorders**	16,272 (15,979-16,546)	17,033 (16,334-17,731)	0.13
Chronic Pulmonary Disease**	14,238 (13,678-14,797)	15,672 (14,379-16,966)	0.65
Diabetes, Uncomplicated**	11,817 (11,681-11,954)	12,653 (12,338-12,968)	0.54
Diabetes, Complicated**	13,384 (13,206-13,563)	14,041 (13,600-14,482)	0.05
Hypothyroidism**	11,672 (11,518-11,826)	12,988 (12,610-13,366)	0.04
Renal Failure**	13,205 (13,040-13,370)	14,274 (13,863-14,685)	0.93
Liver Disease**	15,372 (14,966-15,779)	17,610 (16,365-18,855)	0.13
Peptic Ulcer Diseases Excluding Bleeding**	14,447 (13,602-15,291)	15,692 (13,582-17,803)	0.93
AIDS/HIV**	13,820 (12,700-14,940)	13,511 (9,245-17,776)	0.55
Lymphoma**	14,538 (13,549-15,528)	15,201 (12,860-17,543)	0.72
Metastatic Cancer**	15,918 (15,245-16,592)	14,996 (13,546-16,446)	0.01
Solid Tumor Without Metastasis**	14,177 (13,813-14,541)	14,529 (13,705-15,352)	0.10
Rheumatoid Arthritis/Collagen**	12,046 (11,735-12,357)	13,812 (13,023-14,602)	0.05
Coagulopathy**	17,572 (17,157-17,987)	21,292 (19,983-22,601)	0.00
Obesity**	12,660 (12,516-12,803)	13,950 (13,574-14,326)	0.18
Weight Loss**	16,316 (16,001-16,630)	17,128 (16,368-17,888)	0.22
Fluid and Electrolyte Imbalance**	14,392 (14,267-14,517)	15,052 (14,571-15,352)	0.00
Blood Loss Anemia**	18,381 (17,026-19,736)	17,423 (14,639-20,206)	0.15
Deficiency Anemia**	14,375 (14,022-14,728)	15,613 (14,740-16,487)	0.84
Alcohol Abuse**	12,968 (12,691-13,244)	14,611 (13,799-15,424)	0.16
Drug Abuse**	13,306 (13,029-13,582)	14,217 (13,302-15,131)	0.68
Psychosis**	13,476 (13,065-13,888)	13,833 (12,673-14,993)	0.26
Depression**	11,966 (11,823-12,107)	13,265 (12,909-13,621)	0.04

*** P-value for interaction was obtained by including the interaction term for nonmetropolitan variable separately with each variable**
****no missing data**

Table 13 presents the mean total costs for patients with COPD who had a readmission in 30 days, focusing on comorbidities. The p-values for the interaction results are shown in the last column. I focused on the results in which the interaction effects were significant. Among

readmitted patients with COPD and cardiac arrhythmias, those from nonmetropolitan areas had higher mean total costs than those from metropolitan areas ($23,786 vs. $19,913). Among patients with uncomplicated hypertension, those from nonmetropolitan areas had higher mean total costs than those from metropolitan areas ($19,078 vs. $16,015). This was also the case for those with coagulopathy ($37,100 vs. $26,496), obesity ($22,725 vs. $18,223), and depression ($20,665 vs. $16,585). Among patients with solid tumors without metastasis, those from metropolitan areas had slightly higher mean total costs than those from nonmetropolitan areas ($20,847 vs. $20,466).

Table 13. Margins Stratified by Metropolitan/Nonmetropolitan for Comorbidities Related to Total Hospital Cost for Patients who were Readmitted

Comorbidities (Present)	Metropolitan ($) (95% CI)	Nonmetropolitan ($) (95% CI)	P-Value for Interaction Term*
Congestive Heart Failure**	19,250 (18,862-19,638)	21,843 (20,805-22,880)	0.86
Cardiac Arrhythmia**	19,913 (19,489-20,337)	23,786 (22,587-24,985)	0.01
Valvular Disease**	19,170 (18,348-19,993)	22,558 (20,164-24,952)	0.48
Pulmonary Circulation Disorders**	21,077 (20,333-21,822)	26,025 (23,671-28,379)	0.07
Peripheral Vascular Disorders**	18,618 (17,943-19,292)	20,857 (19,089-22,624)	0.83
Hypertension, Uncomplicated**	16,015 (15,739-16,292)	19,078 (18,282-19,875)	0.00
Hypertension, Complicated**	18,657 (18,161-19,152)	22,417 (20,920-23,915)	0.08
Paralysis**	34,013 (29,494-38,532)	40,972 (28,299-53,646)	0.71
Other Neurologic Disorders**	23,789 (22,901-24,677)	28,800 (26,159-31,441)	0.17
Chronic Pulmonary Disease**	18,886 (17,283-20,489)	26,126 (21,274-30,978)	0.05
Diabetes, Uncomplicated**	16,256 (15,806-16,707)	18,566 (17,362-19,770)	0.75
Diabetes, Complicated**	19,418 (18,830-20,007)	21,022 (19,423-22,620)	0.20
Hypothyroidism**	16,376 (15,836-16,916)	19,117 (17,660-20,574)	0.41
Renal Failure**	18,483 (17,972-18,993)	21,458 (20,023-22,894)	0.46
Liver Disease**	22,377 (21,115-23,640)	29,714 (24,898-34,531)	0.07
Peptic Ulcer Diseases Excluding Bleeding**	20,887 (18,312-23,463)	27,844 (19,498-36,190)	0.32
AIDS/HIV**	19,949 (16,432-23,465)	21,114 (4,058-38,170)	0.87
Lymphoma**	20,761 (17,708-23,814)	26,995 (18,287-35,702)	0.44
Metastatic Cancer**	22,402 (20,598-24,206)	21,920 (17,537-26,303)	0.18
Solid Tumor Without Metastasis**	20,847 (19,963-22,002)	20,467 (17,941-22,993)	0.04
Rheumatoid Arthritis/Collagen**	17,715 (16,582-18,848)	21,902 (18,710-25,095)	0.26
Coagulopathy**	26,496 (25,219-27,772)	37,100 (32,329-41,871)	0.00
Obesity**	18,223 (17,718-18,728)	22,725 (21,127-24,322)	0.01
Weight Loss**	25,350 (24,314-26,385)	27,408 (24,710-30,107)	0.36
Fluid and Electrolyte Imbalance**	21,401 (20,976-21,825)	23,721 (22,579-24,863)	0.17
Blood Loss Anemia**	23,082 (20,083-26,081)	24,413 (16,597-32,228)	0.70
Deficiency Anemia**	20,263 (19,151-21,376)	23,878 (20,737-27,020)	0.58
Alcohol Abuse**	17,439 (16,571-18,306)	21,316 (18,205-24,428)	0.32
Drug Abuse**	16,985 (16,132-17,658)	19,808 (16,814-22,801)	0.65
Psychosis**	18,473 (17,200-19,747)	20,282 (16,223-24,342)	0.78
Depression**	16,585 (16,112-17,059)	20,665 (19,245-22,085)	0.00

*** P-value for interaction was obtained by including the interaction term for nonmetropolitan variable separately with each variable**
****no missing data**

3.3 Discussion

My overall objective in this study was to examine how individual and hospital-level factors are associated with hospital costs of patients with COPD and to explore differences in these costs among patients from nonmetropolitan or metropolitan areas. Regarding my first aim, factors related to increased hospital costs included length of stay: patients who had a length of stay of 4 or more days had higher costs of care regardless of area of residence and were also higher among patients who had a readmission in 30 days. These results were consistent with

those of previous studies. Torabipour et al. (2016) found that a length of stay greater than 9 days was a hospital cost driver. Li et al. (2018) and Yu et al. (2023) also found that length of stay predicted increased cost.

Patients from nonmetropolitan areas in the three highest household income categories had higher costs than patients in those same household income categories from metropolitan areas. This result is not consistent with previous research in which the authors found that lower household income was associated with higher care costs (Prieto-Centurion et al., 2013). This result could be due in part to patients with COPD, who have lower incomes, may be less likely to seek care due to the inability to pay, and have less access to care. Less access to services for people in rural areas and worse overall health could lead to a need for greater resources once admitted to the hospital, which could also be a driver of the overall cost of care (Gaffney et al., 2022). Lowe et al. (2018) found that a larger percentage of low-income subjects with COPD lacked health insurance compared to higher-income subjects. Lowe et al. (2018) also found that patients with lower incomes reported limiting physician visits or not filling prescriptions in response to a lack of insurance coverage. Rural residence and poverty have been shown to be predictors of poorer health outcomes in patients with COPD (Moore et al., 2019; Gaffney et al., 2022).

I found that readmissions within 30 days were associated with higher total costs for patients from nonmetropolitan and metropolitan areas. Villegas et al. (2021) determined that COPD exacerbations that lead to a readmission directly impact cost. This result is consistent with research by Lokke et al. (2021), who found that readmissions were a driver of direct costs. Patients with COPD who live in rural areas may have less access to services and thus may have an increased likelihood of readmission, which could lead to higher hospital costs. One treatment

modality that has been shown to decrease the likelihood of readmission is pulmonary rehabilitation (Myers et al., 2021). Sabit et al. (2008) found that having to commute long distances to a facility that offers pulmonary rehabilitation was a predictor of poor attendance.

Turning to aim two, differences in costs among patients living in nonmetropolitan areas and those living in metropolitan areas, among patients from nonmetropolitan areas, total hospital costs for those ages 55-64 were, on average, $600 higher compared to those ages 40-54. The average costs of those living in metropolitan areas were $2600 higher between these same age groups. These results were not surprising, as age is often associated with higher hospital costs (Alemayehu & Warner, 2004). An area of concern is that patients with COPD who were aged 55 to 64 had higher overall costs than patients 65 years and older (Tables 2 and 3). Patients 55 to 64 are usually employed, which has an impact on not only direct but indirect costs. Patients with COPD who are 55-64 may have more missed days of work. Patel et al. (2014) reported that patients with COPD of working age have a mean annual sick leave or disability days of between 1.3 to 19.4 days compared to patients without COPD. Patel et al. (2014), in looking at the indirect costs of COPD, found that patients of working age with COPD often experience lost wages due to absenteeism and the potential for disability. Patel et al. (2018) found that working-age patients with COPD had higher direct and indirect costs.

The present study found that male patients with COPD had greater costs than female patients; this was true among those living in nonmetropolitan and metropolitan areas. Lisspers et al. (2019) found comparable results. One reason for my findings could be that males have a higher prevalence of COPD as compared to females. Boers et al. (2023) predict that the cases of males with COPD will continue to outpace the cases of females with COPD. A study by Jacobs

et al. (2018) found decreased odds of readmission in 3-days, 7-days, and 30-days in females compared to males. This could also explain the variance in cost between males and females.

The third aim examined the associations of comorbidities and costs and studied whether costs differed among patients living in nonmetropolitan and metropolitan areas. Patients from nonmetropolitan or metropolitan patients with 4-5 comorbidities spent, on average, $3000 more on care compared to those with only 0-2 comorbidities. Thirty-one percent of all patients in my study who were readmitted in 30 days had between 6 and 14 comorbid conditions. These patients also had the highest mean total cost, and the difference related to mean total cost between nonmetropolitan and metropolitan patients was significant. Readmissions for patients with COPD are strongly associated with more comorbidities (Sridhara & Acharya, 2021).

Larsen et al. (2022) found that medical costs of patients with COPD who also had 3 or more comorbid conditions had a cost increase of about $14,000 when compared to patients with COPD who had 1-2 other comorbid conditions. Dong et al. (2021) found that the number of comorbid conditions was significantly associated with longer length of stay in patients with COPD. Gaffney et al. (2022) reported that patients with COPD living in rural areas have more comorbid conditions compared to patients with COPD living in urban areas. This could explain the large cost variance found in this study regarding patients with COPD living in nonmetropolitan areas.

When looking at the associations of specific comorbidities and costs in patients with COPD, congestive heart failure and uncomplicated hypertension were associated with higher costs, and costs were significantly higher among patients in nonmetropolitan areas. When considering patients with COPD who also had a 30-day readmission, cardiac arrhythmias, and uncomplicated hypertension were factors that led to increased overall costs in nonmetropolitan

patients as compared to metropolitan patients. These results are consistent with research by Dalal et al. (2011), who found that patients with COPD and cardiovascular disease had an increase in costs, and by Perera et al. (2012) who found that patients with COPD and depression had higher costs and higher readmission rates. Zhao et al. (2024) found similar results in patients with COPD who also had anxiety and depression. Nonmetropolitan patients with COPD who also had coagulopathy had higher costs as compared to metropolitan patients with COPD and coagulopathy. This was also seen in patients with COPD who were readmitted in 30 days. Cavailles et al. (2013) found that patients with COPD have a high incidence of coagulopathy, and this was due to systemic inflammation that occurs in patients with COPD.

3.4 Strengths

The Nationwide Readmissions Database (NRD) allows for access to a large sample of inpatient data. This dataset contains data from 28 states, allowing researchers to examine trends across many areas of the United States. The NRD dataset provides the opportunity to examine multiple patient conditions and allows for subgroup analysis. The focus of the paper was to determine hospital costs for patients diagnosed with COPD and also to determine if differences exist in patients in nonmetropolitan versus metropolitan areas. COPD continues to cause a huge healthcare burden. Rural and urban differences associated with hospital costs among patients with COPD are an understudied topic.

3.5 Limitations

The NRD data include discharges from 28 states, limiting its generalizability. Miscoding and misdiagnosis can occur in hospital discharge data; however, HCUP data is quality checked and has a low percentage of missing data. Patients might seek care in metropolitan areas due to limited resources in nonmetropolitan areas. HCUP data also has limited clinical information,

which does not allow researchers to control for other health conditions, including limitations in activities of daily living and self-reported health. HCUP data does not provide patient-level electronic medical records to provide a complete episode of care.

3.6 Conclusion

Patients diagnosed with COPD with a higher length of stay, higher income, and more comorbidities had higher hospital costs, with substantially higher costs among patients with more comorbidities. Patients who were readmitted also had higher costs. Compared with patients from metropolitan areas, costs were higher among patients from nonmetropolitan areas for many of the comorbid conditions. Taken as a whole, hospital costs for patients diagnosed with COPD are substantial, with evidence of higher costs for those from nonmetropolitan areas. It would be useful for future research to further examine costs of COPD hospitalization by area of residence.

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CONCLUSION

Overall Aims and Results

Readmission

The first aim of this study was to identify factors related to 30-day readmissions in patients diagnosed with COPD. Males had higher odds of readmission compared to females. Patients with a length of stay more than 4 days had increased odds of readmission. Other research has shown that a length of stay greater than 4 days leads to up to a 2-fold increase in readmission rates for patients with COPD (Alqahtani et al., 2020; Rinne et al., 2017). When assessing insurance type, patients with Medicare, Medicaid, and Worker's Compensation, CHAMPUS, or CHAMPVA had increased odds of readmission. My research indicates that patients with COPD receiving Medicaid had a higher rate of readmission, consistent with previous studies (Simmering et al., 2016; Jiang et al., 2018). In my research, those with a household income of less than $43,000 had 11% increased odds of readmission compared to those with a household income of more than $75,000. Murray et al. (2021) reported patients with COPD with a household income of less than $37,999 had 1.05 times increased odds of 30-day readmission compared to patients with COPD in the highest household income quartile. I found that having a higher number of comorbidities was associated with higher odds of readmission; this result was consistent with that of previous studies (Njoku et al., 2020; Ruan et al., 2023; Simmering et al., 2016).

The second aim examined differences in COPD readmission rates among patients living in nonmetropolitan areas and those living in metropolitan areas. Patients living in metropolitan areas had 10% higher odds of readmission than those living in nonmetropolitan areas. I found a statistically significant difference in readmission rates among patients with COPD living in

nonmetropolitan areas who received Worker's Compensation or were enrolled in CHAMPUS, CHAMPVA, or other governmental programs compared to patients with COPD who received Workers' Compensation or were enrolled in CHAMPUS, CHAMPVA, or other governmental programs in metropolitan areas.

The third aim assessed the effects of comorbid conditions on COPD 30-day readmission rates and examined if these effects varied by rurality. I found that patients with COPD with congestive heart failure and cardiac arrhythmias had 30% increased odds of readmission. Chow et al. (2023) found that comorbidities such as heart failure, diabetes, chronic kidney disease, and cancer were strong predictors of all-cause readmissions in patients with COPD. I found that patients with COPD living in metropolitan areas with neurologic disorders, uncomplicated and complicated diabetes, peptic ulcer disease, AIDS/HIV, metastatic cancer, blood loss anemia, alcohol abuse, and drug abuse had increased odds of readmission compared to patients living in nonmetropolitan areas with these same conditions. In contrast, patients living in nonmetropolitan areas with solid tumors with metastasis, renal failure, peripheral vascular disorders, pulmonary circulation disorders, valvular disease, and cardiac arrhythmias had increased odds of readmission compared to patients living in metropolitan areas with these same comorbid conditions.

Mortality

The first aim of this study was to determine whether certain patient and hospital characteristics were associated with increased odds of inpatient mortality in patients diagnosed with COPD. I found that patients with COPD who were 75+ years of age had 3 times higher odds of inpatient mortality than patients who were 40-54 years of age. The type of insurance that patients held also had an association with inpatient mortality. Patients with COPD with

Medicaid, private insurance, Worker's Compensation, CHAMPUS, or CHAMPVA had higher odds of mortality than those with Medicare. When looking at hospital size, being admitted to a large hospital was associated with an increased odds of inpatient mortality compared with being admitted to a small hospital. Higher odds of inpatient mortality were also associated with what divisions of the country the patient was admitted to. Patients with COPD who were admitted to hospitals in the East South Central and Pacific Divisions had higher odds of mortality compared to patients with COPD who were admitted to hospitals in the New England Divisions. The East South-Central Division includes the states of Kentucky, Tennessee, Mississippi, and Alabama. Sullivan et al. (2018) also reported worse outcomes in patients with COPD in states in Appalachia, the Mississippi Delta, and the South.

In the second aim, my study compared inpatient mortality among patients with COPD living in nonmetropolitan areas and those living in metropolitan areas. When stratifying for residence, among patients with COPD who were 75+, those who lived in metropolitan areas had slightly higher odds of mortality compared to those who lived in nonmetropolitan areas. Male patients had higher odds of mortality than female patients, and the odds of mortality were higher if they lived in a metropolitan area. Park et al. (2019) stated that sex and age were predictors of long-term survival in patients with COPD. Survival probability decreased for males and decreased as patients aged (Park et al., 2019).

In the third aim, I explored the effects of comorbid conditions on inpatient mortality and examined whether these effects varied by residence. I found that the odds of inpatient mortality differed by place of patient residence for metastatic cancer, pulmonary circulation disorders, and fluid and electrolyte imbalance. I found that patients who had pulmonary circulation disorders had increased odds of mortality, but no difference in odds of mortality was found when assessing

a difference related to rurality. I found that patients with liver disease had a two-fold increase in the odds of mortality for those living in metropolitan areas. Sin et al. (2006) found that patients with COPD who also had cardiovascular disease and lung cancer had increased mortality rates.

Cost

Regarding my first aim, one factor related to increased hospital costs was length of stay. Patients who had a length of stay of 4 or more days had higher costs regardless of area of residence; costs were also higher among patients who had a readmission in 30 days and had a length of stay of greater than 4 days. When looking at household income, the location of residence was associated with hospital costs. Patients from nonmetropolitan areas in the three highest household income categories had higher costs than those in metropolitan areas. I found readmissions within 30 days were associated with higher costs for patients living in both nonmetropolitan and metropolitan areas.

Turning to aim two, patients from nonmetropolitan areas who were between the ages of 55 and 64 had higher costs compared to nonmetropolitan patients between the ages of 40 to 54. Among those living in metropolitan areas, average costs were also higher between these same age groups. I also found that male patients had greater costs than female patients and this was true among those living in both nonmetropolitan and metropolitan areas. Lisspers et al. (2019) also found that male patients with COPD had higher overall costs of care compared to female patients with COPD.

The third aim examined the associations of comorbidities and costs and studied whether costs differed among patients living in nonmetropolitan and metropolitan areas. Patients from nonmetropolitan or metropolitan areas who had 4-5 comorbidities spent, on average, $3,000 more on care per admission as compared to those with only 0-2 comorbidities. Patients who were

readmitted within 30 days also had the highest costs, and the difference related to costs between nonmetropolitan and metropolitan patients was significant. When looking at the associations of specific comorbidities and costs, having congestive heart failure and uncomplicated hypertension was associated with higher costs, and costs were significantly higher among patients in nonmetropolitan areas. Huber et al. (2015) showed that comorbidities in patients with COPD were associated with higher costs. They found that direct costs for care were 135% higher if the patients had COPD and cardiovascular disease (Huber et al., 2015). Westney et al. (2017) found that comorbidities in patients with COPD led to an increased utilization of services and an increase in costs, especially in patients who received Medicaid. When considering patients with COPD who also had a 30-day readmission, having cardiac arrhythmias and uncomplicated hypertension was associated with higher costs in patients living in nonmetropolitan areas compared with those living in metropolitan areas. Patients living in nonmetropolitan and patients who had coagulopathy had higher costs compared with those living in metropolitan areas; this result was also the case among those readmitted in 30 days.

Overall Implications of Dissertation

Limitations

I used the Nationwide Readmission Database (NRD) dataset for both the readmission and cost studies. The NRD data include discharges from 28 states, limiting its generalizability. Miscoding and misdiagnosis can occur in hospital discharge data; however, HCUP data is quality checked and has a low percentage of missing data. HCUP data also has limited clinical information, which does not allow researchers to control for other health conditions, including limitations in activities of daily living and self-reported health. HCUP data does not provide patient-level electronic medical records to provide a complete episode of care that could

potentially lead to variables not identified in the study to lead to a readmission. This analysis was conducted prior to the COVID-19 pandemic, and leading causes of hospitalization have changed substantially (CDC, n.d.).

I used the National (Nationwide) Inpatient Sample (NIS) dataset for the mortality study. The NIS data include discharges from 47 states, somewhat limiting its generalizability. Miscoding and misdiagnosis can occur in hospital discharge data; however, HCUP data is quality checked and has a low percentage of missing data. HCUP data has limited clinical information, which does not allow researchers to control for many other factors that may be associated with health and inpatient mortality, including limitations in activities of daily living, self-reported health, social support, and marital status. HCUP data does not provide patient-level electronic medical records needed to provide a complete episode of care that could potentially lead to variables not identified in the study to lead to increased odds of mortality. My analysis was conducted prior to the COVID-19 pandemic, and leading causes of mortality have changed dramatically (CDC, n.d.).

Strengths

The NRD dataset allows for access to a large sample. This dataset contains data from 28 states, which allowed me to examine trends across many areas of the United States. The large sample size allowed me to look at multiple patient conditions and various subgroups.

The focus of the readmission study was to determine readmission rates for patients diagnosed with COPD and to also determine if differences exist in patients in nonmetropolitan versus metropolitan areas. This study supports the conclusion that readmissions for patients with COPD continue to be a burden on healthcare. Few researchers have studied what factors affect readmission rates in patients in nonmetropolitan areas versus metropolitan areas.

The focus of the cost study was to determine hospital costs for patients diagnosed with COPD and to also determine if differences exist in patients in nonmetropolitan versus metropolitan areas. COPD continues to have a significant burden on healthcare costs. Nonmetropolitan and metropolitan differences associated with hospital costs among patients with COPD is an understudied topic.

The NIS dataset allowed me to access a large sample of inpatient data from nearly all U.S. states and the District of Columbia. The large sample size allowed me to examine multiple patient conditions and various subgroup analyses.

The focus of the mortality study was on factors that increase the odds of mortality in patients with COPD. COPD continues to be a leading cause of death and hospitalizations across the U.S. and the world. Gaps in healthcare for rural residents are well documented, especially in patients diagnosed with chronic conditions. The focus of the research study was to look for differences in mortality in patients with COPD in nonmetropolitan and metropolitan areas, an understudied area of research. This study identified several factors that contribute to mortality in patients with COPD and helped to gain a deeper understanding of differences in mortality in patients with COPD who live in nonmetropolitan areas compared to those living in metropolitan areas.

Directions for Future Research and Implications for Health Services Research

Cost, mortality, and readmission rates are outcome assessment tools often used in health services research. By determining factors that have a direct impact on readmission, mortality, and cost, healthcare providers can adjust resources to areas with the highest need. Gaps in care still exist for patients who live in rural areas, and there is evidence that the gap is widening. Research that examines differences by area of residence can help researchers understand the reasons for adverse outcomes in rural areas.

In this dissertation, I examined three outcomes that have the largest impact on the overall health of patients diagnosed with COPD. Readmission rates continue to have a negative impact on the overall health of patients with COPD. It is important to continue to look at trends in readmission rates, especially in patients who live in nonmetropolitan areas. It would be useful for future studies to examine the demographic characteristics I explored in this dissertation and to assess their impact on readmission rates.

Mortality for patients with COPD continues to be a significant challenge for health care providers. Mortality in male patients with COPD was higher in this study, and it would be useful to determine if this trend still exists. Type of insurance was associated with mortality. It would be useful for future research to determine if these trends still exist. One last area of concern is the difference in mortality based on hospital location. I found that patients living in states such as Kentucky, Tennessee, Mississippi, and Alabama had higher odds of mortality. Disparities in outcomes related to mortality in certain geographic areas should be studied further to determine if these areas lack the appropriate resources to manage patients with COPD.

The results of the cost study supported previous research and identified some areas that need future investigation. A deeper dive into the impact of the effect of comorbidities needs to be done. Certain comorbid conditions are directly related to the physiologic changes that occur with COPD. An area of concern is whether providers are working to identify these comorbid conditions and are adjusting care plans accordingly.

It would be useful to use future years of the NRD and NIS datasets to determine if the outcomes found in this dissertation exist or if there is a shift to new variables that are impacting outcomes. While these datasets do not track the same patients over time, general inferences about the overall population of patients with COPD can be made. It will be especially useful to

examine the effects that COVID-19 has had on patient outcomes for patients with COPD. Beginning in 2020, NRD and NIS datasets will now contain the ICD-10 diagnostic codes for COVID-19. Future research in patients with COPD should examine the effects that COVID-19 has on readmission, mortality, and costs.

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APPENDIX: SAS AND STATA CODE

SAS Code for Article One

```
data WORK.NRD    ;
   %let _EFIERR_ = 0; /* set the ERROR detection macro variable */
   infile 'C:\Users\LInabnit\Documents\NRD_2016\NRD_2016\NRD_2016_Core.csv' delimiter
= ',' MISSOVER DSD lrecl=32767 firstobs=2 ;
PROC FORMAT;
  INVALUE N2PF
    '-9' = .
    '-8' = .A
    '-6' = .C
    '-5' = .N
    OTHER = (|2.|)
  ;
  INVALUE N3PF
    '-99' = .
    '-88' = .A
    '-66' = .C
    OTHER = (|3.|)
  ;
  INVALUE N4PF
    '-999' = .
    '-888' = .A
    '-666' = .C
    OTHER = (|4.|)
  ;
  INVALUE N4P1F
    '-9.9' = .
    '-8.8' = .A
    '-6.6' = .C
    OTHER = (|4.1|)
  ;
  INVALUE N5PF
    '-9999' = .
    '-8888' = .A
    '-6666' = .C
    OTHER = (|5.|)
  ;
  INVALUE N5P2F
    '-9.99' = .
    '-8.88' = .A
    '-6.66' = .C
    OTHER = (|5.2|)
```

```
;
INVALUE N6PF
  '-99999' = .
  '-88888' = .A
  '-66666' = .C
  OTHER = (|6.|)
;
INVALUE N6P2F
  '-99.99' = .
  '-88.88' = .A
  '-66.66' = .C
  OTHER = (|6.2|)
;
INVALUE N7P2F
  '-999.99' = .
  '-888.88' = .A
  '-666.66' = .C
  OTHER = (|7.2|)
;
INVALUE N8PF
  '-9999999' = .
  '-8888888' = .A
  '-6666666' = .C
  OTHER = (|8.|)
;
INVALUE N8P2F
  '-9999.99' = .
  '-8888.88' = .A
  '-6666.66' = .C
  OTHER = (|8.2|)
;
INVALUE N8P4F
  '-99.9999' = .
  '-88.8888' = .A
  '-66.6666' = .C
  OTHER = (|8.4|)
;
INVALUE N10PF
  '-999999999' = .
  '-888888888' = .A
  '-666666666' = .C
  OTHER = (|10.|)
;
INVALUE N10P4F
  '-9999.9999' = .
  '-8888.8888' = .A
```

```
  '-6666.6666' = .C
  OTHER = (|10.4|)
 ;
 INVALUE N10P5F
  '-999.99999' = .
  '-888.88888' = .A
  '-666.66666' = .C
  OTHER = (|10.5|)
 ;
 INVALUE DATE10F
  '-999999999' = .
  '-888888888' = .A
  '-666666666' = .C
  OTHER = (|MMDDYY10.|)
 ;
 INVALUE N11P7F
  '-99.9999999' = .
  '-88.8888888' = .A
  '-66.6666666' = .C
  OTHER = (|11.7|)
 ;
 INVALUE N12P2F
  '-99999999.99' = .
  '-88888888.88' = .A
  '-66666666.66' = .C
  OTHER = (|12.2|)
 ;
 INVALUE N12P5F
  '-99999.99999' = .
  '-88888.88888' = .A
  '-66666.66666' = .C
  OTHER = (|12.5|)
 ;
 INVALUE N13PF
  '-999999999999' = .
  '-888888888888' = .A
  '-666666666666' = .C
  OTHER = (|13.|)
 ;
 INVALUE N15P2F
  '-99999999999.99' = .
  '-88888888888.88' = .A
  '-66666666666.66' = .C
  OTHER = (|15.2|)
 ;
RUN;
```

```
/* Data Step to load the file */
DATA NRD_2016_Core;
infile 'C:\Users\LInabnit\Documents\NRD_2016\NRD_2016\NRD_2016_Core.csv' dsd dlm=','
LRECL = 655;
/* Define data element attributes */
ATTRIB
  AGE                    LENGTH=3
  LABEL="Age in years at admission"
  AWEEKEND               LENGTH=3
  LABEL="Admission day is a weekend"
  DIED                   LENGTH=3
  LABEL="Died during hospitalization"
  DISCWT                 LENGTH=8
  LABEL="Weight to discharges in AHA universe"
  DISPUNIFORM            LENGTH=3
  LABEL="Disposition of patient (uniform)"
  DMONTH                 LENGTH=3
  LABEL="Discharge month"
  DQTR                   LENGTH=3
  LABEL="Discharge quarter"
  DRG                    LENGTH=3
  LABEL="DRG in effect on discharge date"
  DRGVER                 LENGTH=3
  LABEL="DRG grouper version used on discharge date"
  DRG_NoPOA              LENGTH=3
  LABEL="DRG in use on discharge date, calculated without POA"
  I10_DX1                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 1"
  I10_DX2                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 2"
  I10_DX3                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 3"
  I10_DX4                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 4"
  I10_DX5                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 5"
  I10_DX6                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 6"
  I10_DX7                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 7"
  I10_DX8                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 8"
  I10_DX9                LENGTH=$7
  LABEL="ICD-10-CM Diagnosis 9"
```

```
I10_DX10              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 10"
I10_DX11              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 11"
I10_DX12              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 12"
I10_DX13              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 13"
I10_DX14              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 14"
I10_DX15              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 15"
I10_DX16              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 16"
I10_DX17              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 17"
I10_DX18              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 18"
I10_DX19              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 19"
I10_DX20              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 20"
I10_DX21              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 21"
I10_DX22              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 22"
I10_DX23              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 23"
I10_DX24              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 24"
I10_DX25              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 25"
I10_DX26              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 26"
I10_DX27              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 27"
I10_DX28              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 28"
I10_DX29              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 29"
I10_DX30              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 30"
I10_DX31              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 31"
I10_DX32              LENGTH=$7
LABEL="ICD-10-CM Diagnosis 32"
```

I10_DX33 LENGTH=$**7**
LABEL="ICD-10-CM Diagnosis 33"
I10_DX34 LENGTH=$**7**
LABEL="ICD-10-CM Diagnosis 34"
I10_DX35 LENGTH=$**7**
LABEL="ICD-10-CM Diagnosis 35"
I10_ECAUSE1 LENGTH=$**7**
LABEL="ICD-10-CM External cause 1"
I10_ECAUSE2 LENGTH=$**7**
LABEL="ICD-10-CM External cause 2"
I10_ECAUSE3 LENGTH=$**7**
LABEL="ICD-10-CM External cause 3"
I10_ECAUSE4 LENGTH=$**7**
LABEL="ICD-10-CM External cause 4"
ELECTIVE LENGTH=**3**
LABEL="Elective versus non-elective admission"
FEMALE LENGTH=**3**
LABEL="Indicator of sex"
HCUP_ED LENGTH=**3**
LABEL="HCUP Emergency Department service indicator"
HOSP_NRD LENGTH=**4**
LABEL="NRD hospital identifier"
KEY_NRD LENGTH=**8**
LABEL="NRD record identifier"
LOS LENGTH=**4**
LABEL="Length of stay (cleaned)"
MDC LENGTH=**3**
LABEL="MDC in effect on discharge date"
MDC_NoPOA LENGTH=**3**
LABEL="MDC in use on discharge date, calculated without POA"
I10_NDX LENGTH=**3**
LABEL="ICD-10-CM Number of diagnoses on this record"
I10_NECAUSE LENGTH=**3**
LABEL="ICD-10-CM Number of External cause codes on this record"
I10_NPR LENGTH=**3**
LABEL="ICD-10-PCS Number of procedures on this record"
NRD_DaysToEvent LENGTH=**8**
LABEL="Timing variable used to identify days between admissions"
NRD_STRATUM LENGTH=**3**
LABEL="NRD stratum used for weighting"
NRD_VisitLink LENGTH=$**7**
LABEL="NRD visitlink"
PAY1 LENGTH=**3**
LABEL="Primary expected payer (uniform)"
PL_NCHS LENGTH=**3**
LABEL="Patient Location: NCHS Urban-Rural Code"

I10_PR1 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 1"
I10_PR2 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 2"
I10_PR3 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 3"
I10_PR4 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 4"
I10_PR5 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 5"
I10_PR6 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 6"
I10_PR7 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 7"
I10_PR8 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 8"
I10_PR9 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 9"
I10_PR10 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 10"
I10_PR11 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 11"
I10_PR12 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 12"
I10_PR13 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 13"
I10_PR14 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 14"
I10_PR15 LENGTH=$**7**
LABEL="ICD-10-PCS Procedure 15"
PRDAY1 LENGTH=**4**
LABEL="Number of days from admission to I10_PR1"
PRDAY2 LENGTH=**4**
LABEL="Number of days from admission to I10_PR2"
PRDAY3 LENGTH=**4**
LABEL="Number of days from admission to I10_PR3"
PRDAY4 LENGTH=**4**
LABEL="Number of days from admission to I10_PR4"
PRDAY5 LENGTH=**4**
LABEL="Number of days from admission to I10_PR5"
PRDAY6 LENGTH=**4**
LABEL="Number of days from admission to I10_PR6"
PRDAY7 LENGTH=**4**
LABEL="Number of days from admission to I10_PR7"
PRDAY8 LENGTH=**4**
LABEL="Number of days from admission to I10_PR8"

```
 PRDAY9                  LENGTH=4
 LABEL="Number of days from admission to I10_PR9"
 PRDAY10                 LENGTH=4
 LABEL="Number of days from admission to I10_PR10"
 PRDAY11                 LENGTH=4
 LABEL="Number of days from admission to I10_PR11"
 PRDAY12                 LENGTH=4
 LABEL="Number of days from admission to I10_PR12"
 PRDAY13                 LENGTH=4
 LABEL="Number of days from admission to I10_PR13"
 PRDAY14                 LENGTH=4
 LABEL="Number of days from admission to I10_PR14"
 PRDAY15                 LENGTH=4
 LABEL="Number of days from admission to I10_PR15"
 REHABTRANSFER           LENGTH=3
 LABEL="A combined record involving rehab transfer"
 RESIDENT                LENGTH=3
 LABEL="Patient State is the same as Hospital State"
 SAMEDAYEVENT            LENGTH=$2
 LABEL="Transfer flag indicating combination of discharges involve same day events"
 TOTCHG                  LENGTH=6
 LABEL="Total charges (cleaned)"
 YEAR                    LENGTH=3
 LABEL="Calendar year"
 ZIPINC_QRTL             LENGTH=3
 LABEL="Median household income national quartile for patient ZIP Code"
 DXVER                   LENGTH=3
 LABEL="Diagnosis Version"
 PRVER                   LENGTH=3
 LABEL="Procedure Version"
 ;
/* Read data elements from the CSV file */
INPUT
    AGE                 :N3PF.
    AWEEKEND            :N2PF.
    DIED                :N2PF.
    DISCWT              :N11P7F.
    DISPUNIFORM         :N2PF.
    DMONTH              :N2PF.
    DQTR                :N2PF.
    DRG                 :N3PF.
    DRGVER              :N2PF.
    DRG_NoPOA           :N3PF.
    I10_DX1             :$CHAR7.
    I10_DX2             :$CHAR7.
```

```
I10_DX3             :$CHAR7.
I10_DX4             :$CHAR7.
I10_DX5             :$CHAR7.
I10_DX6             :$CHAR7.
I10_DX7             :$CHAR7.
I10_DX8             :$CHAR7.
I10_DX9             :$CHAR7.
I10_DX10            :$CHAR7.
I10_DX11            :$CHAR7.
I10_DX12            :$CHAR7.
I10_DX13            :$CHAR7.
I10_DX14            :$CHAR7.
I10_DX15            :$CHAR7.
I10_DX16            :$CHAR7.
I10_DX17            :$CHAR7.
I10_DX18            :$CHAR7.
I10_DX19            :$CHAR7.
I10_DX20            :$CHAR7.
I10_DX21            :$CHAR7.
I10_DX22            :$CHAR7.
I10_DX23            :$CHAR7.
I10_DX24            :$CHAR7.
I10_DX25            :$CHAR7.
I10_DX26            :$CHAR7.
I10_DX27            :$CHAR7.
I10_DX28            :$CHAR7.
I10_DX29            :$CHAR7.
I10_DX30            :$CHAR7.
I10_DX31            :$CHAR7.
I10_DX32            :$CHAR7.
I10_DX33            :$CHAR7.
I10_DX34            :$CHAR7.
I10_DX35            :$CHAR7.
I10_ECAUSE1          :$CHAR7.
I10_ECAUSE2          :$CHAR7.
I10_ECAUSE3          :$CHAR7.
I10_ECAUSE4          :$CHAR7.
ELECTIVE            :N2PF.
FEMALE              :N2PF.
HCUP_ED             :N2PF.
HOSP_NRD            :5.
KEY_NRD             :15.
LOS               :N5PF.
MDC               :N2PF.
MDC_NoPOA           :N2PF.
I10_NDX           :N3PF.
```

```
I10_NECAUSE            :N3PF.
I10_NPR               :N3PF.
NRD_DaysToEvent        :N10PF.
NRD_STRATUM            :N5PF.
NRD_VisitLink          :$CHAR7.
PAY1                  :N2PF.
PL_NCHS               :N3PF.
I10_PR1               :$CHAR7.
I10_PR2               :$CHAR7.
I10_PR3               :$CHAR7.
I10_PR4               :$CHAR7.
I10_PR5               :$CHAR7.
I10_PR6               :$CHAR7.
I10_PR7               :$CHAR7.
I10_PR8               :$CHAR7.
I10_PR9               :$CHAR7.
I10_PR10              :$CHAR7.
I10_PR11              :$CHAR7.
I10_PR12              :$CHAR7.
I10_PR13              :$CHAR7.
I10_PR14              :$CHAR7.
I10_PR15              :$CHAR7.
PRDAY1                :N3PF.
PRDAY2                :N3PF.
PRDAY3                :N3PF.
PRDAY4                :N3PF.
PRDAY5                :N3PF.
PRDAY6                :N3PF.
PRDAY7                :N3PF.
PRDAY8                :N3PF.
PRDAY9                :N3PF.
PRDAY10               :N3PF.
PRDAY11               :N3PF.
PRDAY12               :N3PF.
PRDAY13               :N3PF.
PRDAY14               :N3PF.
PRDAY15               :N3PF.
REHABTRANSFER          :N2PF.
RESIDENT              :N2PF.
SAMEDAYEVENT           :$CHAR2.
TOTCHG                :N10PF.
YEAR                  :N4PF.
ZIPINC_QRTL           :N2PF.
DXVER                 :N2PF.
PRVER                 :N2PF.
;
```

```
RUN;
data WORK.NRD    ;
   %let _EFIERR_ = 0; /* set the ERROR detection macro variable */
   infile 'C:\Users\LInabnit\Documents\NRD_2016\NRD_2016\NRD_2016_Hospital.csv'
delimiter = ',' MISSOVER DSD lrecl=32767 firstobs=2 ;
PROC FORMAT;
 INVALUE N2PF
  '-9' = .
  '-8' = .A
  '-6' = .C
  '-5' = .N
  OTHER = (|2.|)
 ;
 INVALUE N3PF
  '-99' = .
  '-88' = .A
  '-66' = .C
  OTHER = (|3.|)
 ;
 INVALUE N4PF
  '-999' = .
  '-888' = .A
  '-666' = .C
  OTHER = (|4.|)
 ;
 INVALUE N4P1F
  '-9.9' = .
  '-8.8' = .A
  '-6.6' = .C
  OTHER = (|4.1|)
 ;
 INVALUE N5PF
  '-9999' = .
  '-8888' = .A
  '-6666' = .C
  OTHER = (|5.|)
 ;
 INVALUE N5P2F
  '-9.99' = .
  '-8.88' = .A
  '-6.66' = .C
  OTHER = (|5.2|)
 ;
 INVALUE N6PF
  '-99999' = .
  '-88888' = .A
```

```
  '-66666' = .C
  OTHER = (|6.|)
;
INVALUE N6P2F
  '-99.99' = .
  '-88.88' = .A
  '-66.66' = .C
  OTHER = (|6.2|)
;
INVALUE N7P2F
  '-999.99' = .
  '-888.88' = .A
  '-666.66' = .C
  OTHER = (|7.2|)
;
INVALUE N8PF
  '-9999999' = .
  '-8888888' = .A
  '-6666666' = .C
  OTHER = (|8.|)
;
INVALUE N8P2F
  '-9999.99' = .
  '-8888.88' = .A
  '-6666.66' = .C
  OTHER = (|8.2|)
;
INVALUE N8P4F
  '-99.9999' = .
  '-88.8888' = .A
  '-66.6666' = .C
  OTHER = (|8.4|)
;
INVALUE N10PF
  '-999999999' = .
  '-888888888' = .A
  '-666666666' = .C
  OTHER = (|10.|)
;
INVALUE N10P4F
  '-9999.9999' = .
  '-8888.8888' = .A
  '-6666.6666' = .C
  OTHER = (|10.4|)
;
INVALUE N10P5F
```

```
  '-999.99999' = .
  '-888.88888' = .A
  '-666.66666' = .C
  OTHER = (|10.5|)
 ;
 INVALUE DATE10F
  '-999999999' = .
  '-888888888' = .A
  '-666666666' = .C
  OTHER = (|MMDDYY10.|)
 ;
 INVALUE N11P7F
  '-99.9999999' = .
  '-88.8888888' = .A
  '-66.6666666' = .C
  OTHER = (|11.7|)
 ;
 INVALUE N12P2F
  '-99999999.99' = .
  '-88888888.88' = .A
  '-66666666.66' = .C
  OTHER = (|12.2|)
 ;
 INVALUE N12P5F
  '-99999.99999' = .
  '-88888.88888' = .A
  '-66666.66666' = .C
  OTHER = (|12.5|)
 ;
 INVALUE N13PF
  '-999999999999' = .
  '-888888888888' = .A
  '-666666666666' = .C
  OTHER = (|13.|)
 ;
 INVALUE N15P2F
  '-99999999999.99' = .
  '-88888888888.88' = .A
  '-66666666666.66' = .C
  OTHER = (|15.2|)
 ;
RUN;
/* Data Step to load the file */
DATA NRD_2016_Hospital;
INFILE 'C:\Users\LInabnit\Documents\NRD_2016\NRD_2016\NRD_2016_Hospital.csv' dsd
dlm=',' LRECL = 66;
```

```
/* Define data element attributes */
ATTRIB
  HOSP_BEDSIZE              LENGTH=3
  LABEL="Bed size of hospital"
  H_CONTRL                  LENGTH=3
  LABEL="Control/ownership of hospital"
  HOSP_NRD                  LENGTH=4
  LABEL="NRD hospital identifier"
  HOSP_URCAT4               LENGTH=3
  LABEL="Hospital urban-rural designation"
  HOSP_UR_TEACH             LENGTH=3
  LABEL="Teaching status of urban hospitals"
  NRD_STRATUM               LENGTH=3
  LABEL="NRD stratum used for weighting"
  N_DISC_U                  LENGTH=5
  LABEL="Number of universe discharges in NRD_STRATUM"
  N_HOSP_U                  LENGTH=3
  LABEL="Number of universe hospitals in NRD_STRATUM"
  S_DISC_U                  LENGTH=4
  LABEL="Number of sample discharges in NRD_STRATUM"
  S_HOSP_U                  LENGTH=4
  LABEL="Number of universe hospitals in NRD_STRATUM"
  TOTAL_DISC                LENGTH=4
  LABEL="Total hospital discharges"
  YEAR                      LENGTH=3
  LABEL="Calendar year"
  ;
/* Read data elements from the CSV file */
INPUT
     HOSP_BEDSIZE            :N2PF.
     H_CONTRL                :N2PF.
     HOSP_NRD                :5.
     HOSP_URCAT4             :N2PF.
     HOSP_UR_TEACH           :N2PF.
     NRD_STRATUM             :N5PF.
     N_DISC_U                :N8PF.
     N_HOSP_U                :N4PF.
     S_DISC_U                :N8PF.
     S_HOSP_U                :N6PF.
     TOTAL_DISC              :N6PF.
     YEAR                    :N4PF.
     ;
RUN;
data WORK.NRD    ;
   %let _EFIERR_ = 0; /* set the ERROR detection macro variable */
```

```
   infile 'C:\Users\LInabnit\Documents\NRD_2016\NRD_2016\NRD_2016_Severity.csv'
delimiter = ',' MISSOVER DSD lrecl=32767 firstobs=2 ;
PROC FORMAT;
  INVALUE N2PF
    '-9' = .
    '-8' = .A
    '-6' = .C
    '-5' = .N
    OTHER = (|2.|)
  ;
  INVALUE N3PF
    '-99' = .
    '-88' = .A
    '-66' = .C
    OTHER = (|3.|)
  ;
  INVALUE N4PF
    '-999' = .
    '-888' = .A
    '-666' = .C
    OTHER = (|4.|)
  ;
  INVALUE N4P1F
    '-9.9' = .
    '-8.8' = .A
    '-6.6' = .C
    OTHER = (|4.1|)
  ;
  INVALUE N5PF
    '-9999' = .
    '-8888' = .A
    '-6666' = .C
    OTHER = (|5.|)
  ;
  INVALUE N5P2F
    '-9.99' = .
    '-8.88' = .A
    '-6.66' = .C
    OTHER = (|5.2|)
  ;
  INVALUE N6PF
    '-99999' = .
    '-88888' = .A
    '-66666' = .C
    OTHER = (|6.|)
  ;
```

```
INVALUE N6P2F
  '-99.99' = .
  '-88.88' = .A
  '-66.66' = .C
  OTHER = (|6.2|)
;
INVALUE N7P2F
  '-999.99' = .
  '-888.88' = .A
  '-666.66' = .C
  OTHER = (|7.2|)
;
INVALUE N8PF
  '-9999999' = .
  '-8888888' = .A
  '-6666666' = .C
  OTHER = (|8.|)
;
INVALUE N8P2F
  '-9999.99' = .
  '-8888.88' = .A
  '-6666.66' = .C
  OTHER = (|8.2|)
;
INVALUE N8P4F
  '-99.9999' = .
  '-88.8888' = .A
  '-66.6666' = .C
  OTHER = (|8.4|)
;
INVALUE N10PF
  '-999999999' = .
  '-888888888' = .A
  '-666666666' = .C
  OTHER = (|10.|)
;
INVALUE N10P4F
  '-9999.9999' = .
  '-8888.8888' = .A
  '-6666.6666' = .C
  OTHER = (|10.4|)
;
INVALUE N10P5F
  '-999.99999' = .
  '-888.88888' = .A
  '-666.66666' = .C
```

```
  OTHER = (|10.5|)
 ;
 INVALUE DATE10F
  '-999999999' = .
  '-888888888' = .A
  '-666666666' = .C
  OTHER = (|MMDDYY10.|)
 ;
 INVALUE N11P7F
  '-99.9999999' = .
  '-88.8888888' = .A
  '-66.6666666' = .C
  OTHER = (|11.7|)
 ;
 INVALUE N12P2F
  '-99999999.99' = .
  '-88888888.88' = .A
  '-66666666.66' = .C
  OTHER = (|12.2|)
 ;
 INVALUE N12P5F
  '-99999.99999' = .
  '-88888.88888' = .A
  '-66666.66666' = .C
  OTHER = (|12.5|)
 ;
 INVALUE N13PF
  '-999999999999' = .
  '-888888888888' = .A
  '-666666666666' = .C
  OTHER = (|13.|)
 ;
 INVALUE N15P2F
  '-99999999999.99' = .
  '-88888888888.88' = .A
  '-66666666666.66' = .C
  OTHER = (|15.2|)
 ;
RUN;
/* Data Step to load the file */
DATA NRD_2016_Severity;
INFILE 'C:\Users\LInabnit\Documents\NRD_2016\NRD_2016\NRD_2016_Severity.csv' dsd
dlm=',' LRECL = 33;
/* Define data element attributes */
ATTRIB
 APRDRG                  LENGTH=3
```

```
 LABEL="All Patient Refined DRG"
 APRDRG_Risk_Mortality     LENGTH=3
 LABEL="All Patient Refined DRG: Risk of Mortality Subclass"
 APRDRG_Severity           LENGTH=3
 LABEL="All Patient Refined DRG: Severity of Illness Subclass"
 HOSP_NRD                  LENGTH=4
 LABEL="NRD hospital identifier"
 KEY_NRD                   LENGTH=8
 LABEL="NRD record identifier"
 ;
/* Read data elements from the CSV file */
INPUT
    APRDRG                 :N4PF.
    APRDRG_Risk_Mortality  :N2PF.
    APRDRG_Severity        :N2PF.
    HOSP_NRD               :5.
    KEY_NRD                :15.
    ;
RUN;
data NRD_2016_All;
merge nrd_2016_core nrd_2016_hospital nrd_2016_severity;
by hosp_nrd;
run;
data NRD_2016_All_Age;
set nrd_2016_All;
if age > = 40;
run;
data NRD_2016_All_COPD;
set work.nrd_2016_All_Age;
copd=0;
array co(35) I10_DX1-I10_DX35;
do i=1 to 35;
if co(i) in ('J40' 'J41' 'J42' 'J43' 'J44') then copd =1;
end;
drop i;
run;
```

STATA Code for Article One

Data file was created using SAS and then imported to STATA for next part of analysis.

```
keep age agegrp discwt dispuniform drg drg_nopoa i10_dx2- i10_dx35 elective female hcup_ed
hosp_nrd key_nrd los i10_ndx nrd_daystoevent nrd_stratum nrd_visitlink pay1 pl_nchs resident
samedayevent zipinc_qrtl indexevent hosp_nrd_readmit daystoreadmission readmit
hosp_bedsize h_contrl hosp_urcat4 hosp_ur_teach aprdrg aprdrg_risk_mortality aprdrg_severity
total_disc i10_dx1 elx_grp_1- elx_grp_31 i total_elixcount nonmetropolitan comorbcondition
```

```
compress
save nrd_2016, replace
clear
cd "C:\Users\linabnit\Google Drive\HCUP_Stata\Master_Data"
capture log close
log using nrd2016.log,replace
use nrd_2016
compress
describe
codebook
 ***- descriptive statistics
*summarize continuous variables
sum age los total_elixcount
*summarize categorical variables
tab1 female agegrp pay1 hosp_bedsize zipinc_qrtl  h_contrl hosp_urcat4 hosp_ur_teach
comorbcondition  readmit nonmetropolitan elx_grp_1-elx_grp_31
tab1 elx_grp_1-elx_grp_31
*Labeling categorical variables
label value female sex
label define sex 0 "Male" 1 "Female"
label value agegrp agelabel
label define agelabel 1 "40-47" 2 "48-55" 3 "56-64" 4 "GE 65"
label value pay1 payers
label define payers 1 "Medicare" 2 "Medicaid" 3 "Private" 4 "Self-Pay" 5 "No Charge" 6 "Other"
label value hosp_bedsize bedsize
label define bedsize 1 "Small" 2 "Medium" 3 "Large"
label value zipinc_qrtl MedianIncome
label define MedianIncome 1 "$1-$42,999" 2 "$43,000-$53,999" 3 "$54,000-$70,999" 4
"$71,000+"
label value h_contrl ownership
label define ownership 1 "Government" 2 "Private Not for Profit" 3 "Private For Profit"
label value hosp_urcat4 urbanruralhosp
label define urbanruralhosp 1 "Large Metro" 2 "Small Metro" 3 "Micro" 4 "Nonmetro"
codebook hosp_ur_teach
label value hosp_ur_teach teaching
label define teaching 0 "Metro Non-Teaching" 1 "Metro Teaching" 2 "Non-Metro"
label value comorbcondition comorb
label define comorb 1 "0-4" 2 "5-10" 3 "11-15"
label value readmit readmission
label define readmission 0 "No Readmission" 1 "Readmission"
codebook nonmetropolitan
label value nonmetropolitan urbanrural
label define urbanrural 0 "Metropolitan" 1 "Nonmetropolitan"
codebook elx_grp_1
label value elx_grp_1 CHF
label define CHF 0 "No CHF" 1 "CHF"
```

```
codebook elx_grp_2
label value elx_grp_2 CardiacArrhythmias
label define CardiacArrhythmias 0 "No Cardiac Arrhythmias" 1 "Cardiac Arrhythmias"
codebook elx_grp_3
label value elx_grp_3 ValvularDisease
label define ValvularDisease 0 "No Valvular Disease" 1 "Valvular Disease"
codebook elx_grp_4
label value elx_grp_4 PulmCircDisorders
label define PulmCircDisorders 0 "No Pulmonary Circulation Disorders" 1 "Pulmonary
Circulation Disorders"
codebook elx_grp_5
label value elx_grp_5 PerVascDisorders
label define PerVascDisorders 0 "No Peripheral Vascular Disorders" 1 "Peripheral Vascular
Disorders"
codebook elx_grp_6
label value elx_grp_6 HTNUncomp
label define HTNUncomp 0 "No HTN Uncomplicated" 1 "HTN Uncomplicated"
codebook elx_grp_7
label value elx_grp_7 HTNComp
label define HTNComp 0 "No HTN Complicated" 1 "HTN Complicated"
codebook elx_grp_8
label value elx_grp_8 Para
label define Para 0 "No Paralysis" 1 "Paralysis"
codebook elx_grp_9
label value elx_grp_9 OtherNeuro
label define OtherNeuro 0 "No Other Neurological Disorders" 1 "Neurological Disorders"
codebook elx_grp_10
label value elx_grp_10 ChroPulm
label define ChroPulm 0 "No Chronic Pulmonary Disease" 1 "Chronic Pulmonary Disease"
codebook elx_grp_11
label value elx_grp_11 DiabetesUncom
label define DiabetesUncom 0 "No Diabetes Uncomplicated" 1 "Diabetes Uncomplicated"
codebook elx_grp_12
label value elx_grp_12 DiabetesCom
label define DiabetesCom 0 "No Diabetes Complicated" 1 "Diabetes Complicated"
codebook elx_grp_13
label value elx_grp_13 Hypothy
label define Hypothy 0 "No Hypothyroidism" 1 "Hypothyroidism"
codebook elx_grp_14
label value elx_grp_14 RenalFail
label define RenalFail 0 "No Renal Failure" 1 "Renal Failure"
codebook elx_grp_15
label value elx_grp_15 LiverDis
label define LiverDis 0 "No Liver Disease" 1 "Liver Disease"
codebook elx_grp_16
label value elx_grp_16 PepticUlcer
```

```
label define PepticUlcer 0 "No Peptic Ulcer Disease" 1 "Peptic Ulcer Disease"
codebook elx_grp_17
label value elx_grp_17 AIDSHIV
label define AIDSHIV 0 "No AIDS/HIV" 1 "AIDS/HIV"
codebook elx_grp_18
label value elx_grp_18 Lymph
label define Lymph 0 "No Lymphoma" 1 "Lymphoma"
codebook elx_grp_19
label value elx_grp_19 MetaCA
label define MetaCA 0 "No Metastatic Cancer" 1 "Metastatic Cancer"
codebook elx_grp_20
label value elx_grp_20 SolidTU
label define SolidTU 0 "No Solid Tumor without Metastasis" 1 "Solid Tumor without
Metastasis"
codebook elx_grp_21
label value elx_grp_21 RA
label define RA 0 "No Rheumatoid Arthritis/collagen" 1 "Rheumatoid Arthritis/collagen"
codebook elx_grp_22
label value elx_grp_22 Coagulo
label define Coagulo 0 "No Coagulopathy" 1 "Coagulopathy"
codebook elx_grp_23
label value elx_grp_23 Obese
label define Obese 0 "No Obesity" 1 "Obesity"
codebook elx_grp_24
label value elx_grp_24 WeightL
label define WeightL 0 "No Weight Loss" 1 "Weight Loss"
codebook elx_grp_25
label value elx_grp_25 FluidElectrolyte
label define FluidElectrolyte 0 "No Fluid and Electrolyte Disorders" 1 "Fluid and Electrolyte
Disorders"
codebook elx_grp_26
label value elx_grp_26 BloodlossA
label define BloodlossA 0 "No Blood Loss Anemia" 1 "Blood Loss Anemia"
codebook elx_grp_27
label value elx_grp_27 DeficiencyA
label define DeficiencyA 0 "No Deficiency Anemia" 1 "Deficiency Anemia"
codebook elx_grp_28
label value elx_grp_28 AA
label define AA 0 "No Alcohol Abuse" 1 "Alcohol Abuse"
codebook elx_grp_29
label value elx_grp_29 DA
label define DA 0 "No Drug Abuse" 1 "Drug Abuse"
codebook elx_grp_30
label value elx_grp_30 Psych
label define Psych 0 "No Psychosis" 1 "Psychosis"
codebook elx_grp_31
```

```
label value elx_grp_31 Depress
label define Depress 0 "No Depression" 1 "Depression"
svyset _n [pweight=discwt], strata(nrd_stratum) vce(linearized) singleunit(missing)
tab1 agegrp female zipinc_qrtl hosp_bedsize hosp_ur_teach comorbcondition, miss
svy:tab agegrp, obs percent format(%9.1f) miss
svy:tab female, obs percent format(%9.1f) miss
svy:tab pay1, obs percent format(%9.1f) miss
svy:tab hosp_bedsize, obs percent format(%9.1f) miss
svy:tab nonmetropolitan, obs percent format(%9.1f) miss
svy:tab hosp_urcat4, obs percent format(%9.1f) miss
svy:tab zipinc_qrtl, obs percent format(%9.1f) miss
svy:tab comorbcondition, obs percent format(%9.1f) miss
*Binary logistic regression
*Unadjusted binary logistic regression
svy:logistic readmit i.agegrp
svy:logistic readmit female
svy:logistic readmit ib3.pay1
svy:logistic readmit ib4.zipinc_qrtl
svy:logistic readmit ib3.hosp_bedsize
svy:logistic readmit nonmetropolitan
svy:logistic readmit i.hosp_ur_teach
svy:logistic readmit i.comorbcondition
list comorbcondition, sep(4)
xtile quart = comorbcondition, nq(4)
list comorbcondition quart, sepby(quart)
list total_elixcount, sep(4)
xtile elixquart = total_elixcount, nq(4)
list total_elixcount elixquart, sepby(elixquart)
*missing data*
tab female, missing
tab pay1, missing
tab losbin, missing
tab zipinc_qrtl, missing
tab elixquart, missing
tab agegrp4, missing
tab age, missing
*New elixquart variable with dummy variable*
sort zipinc_qrtl
by zipinc_qrtl: generate ZIPINCMissing=0
replace ZIPINCMissing=1 if zipinc_qrtl==.
tab zipinc_qrtl, missing
by zipinc_qrtl: generate ZIPINC_QRTL1=0
replace ZIPINC_QRTL1=1 if zipinc_qrtl==1
tab ZIPINC_QRTL1
by zipinc_qrtl: generate ZIPINC_QRTL2=0
replace ZIPINC_QRTL2=1 if zipinc_qrtl==2
```

```
tab ZIPINC_QRTL2
by zipinc_qrtl: generate ZIPINC_QRTL3=0
replace ZIPINC_QRTL3=1 if zipinc_qrtl==3
tab ZIPINC_QRTL3
by zipinc_qrtl: generate ZIPINC_QRTL4=0
replace ZIPINC_QRTL4=1 if zipinc_qrtl==4
tab ZIPINC_QRTL4
generate zipinc=0
replace zipinc=1 if  ZIPINC_QRTL1==1 & ZIPINC_QRTL2==1 & ZIPINC_QRTL3==1 &
ZIPINC_QRTL4==1 & ZIPINCMissing==1
generate CAT1=0
replace CAT1=1 if ZIPINC_QRTL1==1
tab CAT1
generate Cat2=0
replace Cat2=1 if ZIPINC_QRTL2==1
tab Cat2
generate CAT3=0
replace CAT3=1 if ZIPINC_QRTL3==1
tab CAT3
generate CAT4=0
replace CAT4=1 if ZIPINC_QRTL4==1
tab CAT4
generate CAT5=0
replace CAT5=1 if ZIPINCMissing==1
tab CAT5
egen Zipinc = group(CAT1 Cat2 CAT3 CAT4 CAT5)
tab Zipinc
svy:prop Zipinc
*Unadjusted binary logistic regression
svy:logistic readmit i.agegrp4
svy:logistic readmit female
svy:logistic readmit ib3.pay1
svy:logistic readmit ib2.Zipinc
svy:logistic readmit ib3.hosp_bedsize
svy:logistic readmit nonmetropolitan
svy:logistic readmit i.hosp_ur_teach
svy:logistic readmit i.elixquart
svy:logistic readmit
svy:logistic readmit nonmetropolitan##ib2.female
svy:logistic readmit nonmetropolitan##i.elx_grp_1-elx_grp_31
svy:logistic readmit i.elx_grp_1-elx_grp_31
by nonmetropolitan, sort:logistic readmit i.elx_grp_1-elx_grp_31
svy:logistic readmit nonmetropolitan##i.agegrp4
svy:logistic readmit nonmetropolitan##i.losbin
svy:logistic readmit nonmetropolitan##ib3.pay1
svy:logistic readmit nonmetropolitan##ib2.Zipinc
```

```
svy:logistic readmit nonmetropolitan##ib3.hosp_bedsize
svy:logistic readmit nonmetropolitan##ib2.elixquart
*multiple logistic regression
svy:logistic readmit female los ib3.pay1 ib4.zipinc_qrtl ib3.hosp_bedsize ib3.h_contrl
i.hosp_urcat4 i.hosp_ur_teach i.comorbcondition nonmetropolitan
* stratified multiple logistic regression
svy:logistic readmit ib2.female i.agegrp4 i.losbin ib3.pay1 ib2.Zipinc ib3.hosp_bedsize
ib2.nonmetropolitan i.hosp_ur_teach
```

STATA Code for Paper Two

```
set mem 500m
*** Read data elements from the ASCII file ***
infix int    AGE                  1-   3   ///
      byte   AGE_NEONATE              4-   5   ///
      byte   AMONTH                   6-   7   ///
      byte   AWEEKEND                 8-   9   ///
      byte   DIED                    10-  11   ///
      double DISCWT                  12-  22   ///
      byte   DISPUNIFORM             23-  24   ///
      byte   DQTR                    25-  26   ///
      int    DRG                     27-  29   ///
      byte   DRGVER                  30-  31   ///
      int    DRG_NoPOA               32-  34   ///
      byte   DXVER                   35-  36   ///
      byte   ELECTIVE                37-  38   ///
      byte   FEMALE                  39-  40   ///
      int    HCUP_ED                 41-  43   ///
      byte   HOSP_DIVISION           44-  45   ///
      long   HOSP_NIS                46-  50   ///
      str    I10_DX1                 51-  57   ///
      str    I10_DX2                 58-  64   ///
      str    I10_DX3                 65-  71   ///
      str    I10_DX4                 72-  78   ///
      str    I10_DX5                 79-  85   ///
      str    I10_DX6                 86-  92   ///
      str    I10_DX7                 93-  99   ///
      str    I10_DX8                100- 106   ///
      str    I10_DX9                107- 113   ///
      str    I10_DX10               114- 120   ///
      str    I10_DX11               121- 127   ///
      str    I10_DX12               128- 134   ///
      str    I10_DX13               135- 141   ///
      str    I10_DX14               142- 148   ///
      str    I10_DX15               149- 155   ///
      str    I10_DX16               156- 162   ///
```

```
str    I10_DX17              163- 169   ///
str    I10_DX18              170- 176   ///
str    I10_DX19              177- 183   ///
str    I10_DX20              184- 190   ///
str    I10_DX21              191- 197   ///
str    I10_DX22              198- 204   ///
str    I10_DX23              205- 211   ///
str    I10_DX24              212- 218   ///
str    I10_DX25              219- 225   ///
str    I10_DX26              226- 232   ///
str    I10_DX27              233- 239   ///
str    I10_DX28              240- 246   ///
str    I10_DX29              247- 253   ///
str    I10_DX30              254- 260   ///
str    I10_ECAUSE1             261- 267   ///
str    I10_ECAUSE2             268- 274   ///
str    I10_ECAUSE3             275- 281   ///
str    I10_ECAUSE4             282- 288   ///
byte   I10_NDX               289- 290   ///
int    I10_NECAUSE             291- 293   ///
byte   I10_NPR               294- 295   ///
str    I10_PR1               296- 302   ///
str    I10_PR2               303- 309   ///
str    I10_PR3               310- 316   ///
str    I10_PR4               317- 323   ///
str    I10_PR5               324- 330   ///
str    I10_PR6               331- 337   ///
str    I10_PR7               338- 344   ///
str    I10_PR8               345- 351   ///
str    I10_PR9               352- 358   ///
str    I10_PR10              359- 365   ///
str    I10_PR11              366- 372   ///
str    I10_PR12              373- 379   ///
str    I10_PR13              380- 386   ///
str    I10_PR14              387- 393   ///
str    I10_PR15              394- 400   ///
double KEY_NIS                 401- 410   ///
long   LOS                   411- 415   ///
byte   MDC                   416- 417   ///
byte   MDC_NoPOA               418- 419   ///
int    NIS_STRATUM             420- 423   ///
byte   PAY1                  424- 425   ///
int    PL_NCHS               426- 428   ///
int    PRDAY1                429- 431   ///
int    PRDAY2                432- 434   ///
int    PRDAY3                435- 437   ///
```

```
    int   PRDAY4                438- 440   ///
    int   PRDAY5                441- 443   ///
    int   PRDAY6                444- 446   ///
    int   PRDAY7                447- 449   ///
    int   PRDAY8                450- 452   ///
    int   PRDAY9                453- 455   ///
    int   PRDAY10               456- 458   ///
    int   PRDAY11               459- 461   ///
    int   PRDAY12               462- 464   ///
    int   PRDAY13               465- 467   ///
    int   PRDAY14               468- 470   ///
    int   PRDAY15               471- 473   ///
    byte  PRVER                 474- 475   ///
    byte  RACE                  476- 477   ///
    double TOTCHG                  478- 487   ///
    byte  TRAN_IN               488- 489   ///
    byte  TRAN_OUT                 490- 491   ///
    int   YEAR                  492- 495   ///
    byte  ZIPINC_QRTL              496- 497   ///
    using  "NIS_2016_Core.ASC"
*** Assign labels to the data elements ***
label var AGE                 "Age in years at admission"
label var AGE_NEONATE            "Neonatal age (first 28 days after birth) indicator"
label var AMONTH              "Admission month"
label var AWEEKEND               "Admission day is a weekend"
label var DIED                "Died during hospitalization"
label var DISCWT              "NIS discharge weight"
label var DISPUNIFORM            "Disposition of patient (uniform)"
label var DQTR                "Discharge quarter"
label var DRG                 "DRG in effect on discharge date"
label var DRGVER              "DRG grouper version used on discharge date"
label var DRG_NoPOA              "DRG in use on discharge date, calculated without POA"
label var DXVER               "Diagnosis Version"
label var ELECTIVE            "Elective versus non-elective admission"
label var FEMALE              "Indicator of sex"
label var HCUP_ED             "HCUP Emergency Department service indicator"
label var HOSP_DIVISION          "Census Division of hospital"
label var HOSP_NIS            "NIS hospital number"
label var I10_DX1             "ICD-10-CM Diagnosis 1"
label var I10_DX2             "ICD-10-CM Diagnosis 2"
label var I10_DX3             "ICD-10-CM Diagnosis 3"
label var I10_DX4             "ICD-10-CM Diagnosis 4"
label var I10_DX5             "ICD-10-CM Diagnosis 5"
label var I10_DX6             "ICD-10-CM Diagnosis 6"
label var I10_DX7             "ICD-10-CM Diagnosis 7"
label var I10_DX8             "ICD-10-CM Diagnosis 8"
```

```
label var I10_DX9              "ICD-10-CM Diagnosis 9"
label var I10_DX10             "ICD-10-CM Diagnosis 10"
label var I10_DX11             "ICD-10-CM Diagnosis 11"
label var I10_DX12             "ICD-10-CM Diagnosis 12"
label var I10_DX13             "ICD-10-CM Diagnosis 13"
label var I10_DX14             "ICD-10-CM Diagnosis 14"
label var I10_DX15             "ICD-10-CM Diagnosis 15"
label var I10_DX16             "ICD-10-CM Diagnosis 16"
label var I10_DX17             "ICD-10-CM Diagnosis 17"
label var I10_DX18             "ICD-10-CM Diagnosis 18"
label var I10_DX19             "ICD-10-CM Diagnosis 19"
label var I10_DX20             "ICD-10-CM Diagnosis 20"
label var I10_DX21             "ICD-10-CM Diagnosis 21"
label var I10_DX22             "ICD-10-CM Diagnosis 22"
label var I10_DX23             "ICD-10-CM Diagnosis 23"
label var I10_DX24             "ICD-10-CM Diagnosis 24"
label var I10_DX25             "ICD-10-CM Diagnosis 25"
label var I10_DX26             "ICD-10-CM Diagnosis 26"
label var I10_DX27             "ICD-10-CM Diagnosis 27"
label var I10_DX28             "ICD-10-CM Diagnosis 28"
label var I10_DX29             "ICD-10-CM Diagnosis 29"
label var I10_DX30             "ICD-10-CM Diagnosis 30"
label var I10_ECAUSE1          "ICD-10-CM External cause 1"
label var I10_ECAUSE2          "ICD-10-CM External cause 2"
label var I10_ECAUSE3          "ICD-10-CM External cause 3"
label var I10_ECAUSE4          "ICD-10-CM External cause 4"
label var I10_NDX              "ICD-10-CM Number of diagnoses on this record"
label var I10_NECAUSE          "ICD-10-CM Number of External cause codes on this record"
label var I10_NPR              "ICD-10-PCS Number of procedures on this record"
label var I10_PR1              "ICD-10-PCS Procedure 1"
label var I10_PR2              "ICD-10-PCS Procedure 2"
label var I10_PR3              "ICD-10-PCS Procedure 3"
label var I10_PR4              "ICD-10-PCS Procedure 4"
label var I10_PR5              "ICD-10-PCS Procedure 5"
label var I10_PR6              "ICD-10-PCS Procedure 6"
label var I10_PR7              "ICD-10-PCS Procedure 7"
label var I10_PR8              "ICD-10-PCS Procedure 8"
label var I10_PR9              "ICD-10-PCS Procedure 9"
label var I10_PR10             "ICD-10-PCS Procedure 10"
label var I10_PR11             "ICD-10-PCS Procedure 11"
label var I10_PR12             "ICD-10-PCS Procedure 12"
label var I10_PR13             "ICD-10-PCS Procedure 13"
label var I10_PR14             "ICD-10-PCS Procedure 14"
label var I10_PR15             "ICD-10-PCS Procedure 15"
label var KEY_NIS              "NIS record number"
label var LOS                  "Length of stay (cleaned)"
```

```
label var MDC                "MDC in effect on discharge date"
label var MDC_NoPOA          "MDC in use on discharge date, calculated without POA"
label var NIS_STRATUM        "NIS hospital stratum"
label var PAY1               "Primary expected payer (uniform)"
label var PL_NCHS            "Patient Location: NCHS Urban-Rural Code"
label var PRDAY1             "Number of days from admission to I10_PR1"
label var PRDAY2             "Number of days from admission to I10_PR2"
label var PRDAY3             "Number of days from admission to I10_PR3"
label var PRDAY4             "Number of days from admission to I10_PR4"
label var PRDAY5             "Number of days from admission to I10_PR5"
label var PRDAY6             "Number of days from admission to I10_PR6"
label var PRDAY7             "Number of days from admission to I10_PR7"
label var PRDAY8             "Number of days from admission to I10_PR8"
label var PRDAY9             "Number of days from admission to I10_PR9"
label var PRDAY10            "Number of days from admission to I10_PR10"
label var PRDAY11            "Number of days from admission to I10_PR11"
label var PRDAY12            "Number of days from admission to I10_PR12"
label var PRDAY13            "Number of days from admission to I10_PR13"
label var PRDAY14            "Number of days from admission to I10_PR14"
label var PRDAY15            "Number of days from admission to I10_PR15"
label var PRVER              "Procedure Version"
label var RACE               "Race (uniform)"
label var TOTCHG             "Total charges (cleaned)"
label var TRAN_IN            "Transfer in indicator"
label var TRAN_OUT           "Transfer out indicator"
label var YEAR               "Calendar year"
label var ZIPINC_QRTL        "Median household income national quartile for patient ZIP
Code"
*** Convert special values to missing values ***
recode AGE                (-99 -88 -66=.)
recode AGE_NEONATE        (-9 -8 -6 -5=.)
recode AMONTH             (-9 -8 -6 -5=.)
recode AWEEKEND           (-9 -8 -6 -5=.)
recode DIED               (-9 -8 -6 -5=.)
recode DISCWT             (-99.9999999 -88.8888888 -66.6666666=.)
recode DISPUNIFORM        (-9 -8 -6 -5=.)
recode DQTR               (-9 -8 -6 -5=.)
recode DRG                (-99 -88 -66=.)
recode DRGVER             (-9 -8 -6 -5=.)
recode DRG_NoPOA          (-99 -88 -66=.)
recode DXVER              (-9 -8 -6 -5=.)
recode ELECTIVE           (-9 -8 -6 -5=.)
recode FEMALE             (-9 -8 -6 -5=.)
recode HCUP_ED            (-99 -88 -66=.)
recode HOSP_DIVISION      (-9 -8 -6 -5=.)
recode HOSP_NIS           (-9999 -8888 -6666=.)
```

```
recode I10_NDX               (-9 -8 -6 -5=.)
recode I10_NECAUSE           (-99 -88 -66=.)
recode I10_NPR               (-9 -8 -6 -5=.)
recode KEY_NIS               (-999999999 -888888888 -666666666=.)
recode LOS                   (-9999 -8888 -6666=.)
recode MDC                   (-9 -8 -6 -5=.)
recode MDC_NoPOA             (-9 -8 -6 -5=.)
recode NIS_STRATUM           (-999 -888 -666=.)
recode PAY1                  (-9 -8 -6 -5=.)
recode PL_NCHS               (-99 -88 -66=.)
recode PRDAY1                (-99 -88 -66=.)
recode PRDAY2                (-99 -88 -66=.)
recode PRDAY3                (-99 -88 -66=.)
recode PRDAY4                (-99 -88 -66=.)
recode PRDAY5                (-99 -88 -66=.)
recode PRDAY6                (-99 -88 -66=.)
recode PRDAY7                (-99 -88 -66=.)
recode PRDAY8                (-99 -88 -66=.)
recode PRDAY9                (-99 -88 -66=.)
recode PRDAY10               (-99 -88 -66=.)
recode PRDAY11               (-99 -88 -66=.)
recode PRDAY12               (-99 -88 -66=.)
recode PRDAY13               (-99 -88 -66=.)
recode PRDAY14               (-99 -88 -66=.)
recode PRDAY15               (-99 -88 -66=.)
recode PRVER                 (-9 -8 -6 -5=.)
recode RACE                  (-9 -8 -6 -5=.)
recode TOTCHG                (-999999999 -888888888 -666666666=.)
recode TRAN_IN               (-9 -8 -6 -5=.)
recode TRAN_OUT              (-9 -8 -6 -5=.)
recode YEAR                  (-999 -888 -666=.)
recode ZIPINC_QRTL           (-9 -8 -6 -5=.)
save "NIS_2016_Core.dta", replace
*** Set available memory size ***
set mem 500m
*** Read data elements from the ASCII file ***
infix double DISCWT                1-  11   ///
     byte   HOSP_BEDSIZE           12-  13   ///
     byte   HOSP_DIVISION          14-  15   ///
     byte   HOSP_LOCTEACH          16-  17   ///
     long   HOSP_NIS               18-  22   ///
     byte   HOSP_REGION            23-  24   ///
     byte   H_CONTRL               25-  26   ///
     int    NIS_STRATUM            27-  30   ///
     long   N_DISC_U               31-  38   ///
     int    N_HOSP_U               39-  42   ///
```

```
    long   S_DISC_U                43-  50   ///
    int    S_HOSP_U                51-  54   ///
    long   TOTAL_DISC                55-  60   ///
    int    YEAR                    61-  64   ///
    using  "NIS_2016_Hospital.ASC"
***  Assign labels to the data elements ***
label var DISCWT                "NIS discharge weight"
label var HOSP_BEDSIZE          "Bed size of hospital (STRATA)"
label var HOSP_DIVISION         "Census Division of hospital (STRATA)"
label var HOSP_LOCTEACH         "Location/teaching status of hospital (STRATA)"
label var HOSP_NIS              "NIS hospital number"
label var HOSP_REGION           "Region of hospital"
label var H_CONTRL              "Control/ownership of hospital (STRATA)"
label var NIS_STRATUM           "NIS hospital stratum"
label var N_DISC_U              "Number of universe discharges in the stratum"
label var N_HOSP_U              "Number of universe hospitals in the stratum"
label var S_DISC_U              "Number of sample discharges in the stratum"
label var S_HOSP_U              "Number of sample hospitals in the stratum"
label var TOTAL_DISC            "Total number of discharges from this hospital in the NIS"
label var YEAR                  "Calendar year"
*** Convert special values to missing values ***
recode DISCWT                (-99.9999999 -88.8888888 -66.6666666=.)
recode HOSP_BEDSIZE          (-9 -8 -6 -5=.)
recode HOSP_DIVISION         (-9 -8 -6 -5=.)
recode HOSP_LOCTEACH         (-9 -8 -6 -5=.)
recode HOSP_NIS              (-9999 -8888 -6666=.)
recode HOSP_REGION           (-9 -8 -6 -5=.)
recode H_CONTRL              (-9 -8 -6 -5=.)
recode NIS_STRATUM           (-999 -888 -666=.)
recode N_DISC_U              (-9999999 -8888888 -6666666=.)
recode N_HOSP_U              (-999 -888 -666=.)
recode S_DISC_U              (-9999999 -8888888 -6666666=.)
recode S_HOSP_U              (-999 -888 -666=.)
recode TOTAL_DISC            (-99999 -88888 -66666=.)
recode YEAR                  (-999 -888 -666=.)
save "NIS_2016_Hospital.dta", replace
*** Set available memory size ***
set mem 500m
*** Read data elements from the ASCII file ***
infix long   HOSP_NIS                1-   5   ///
    double KEY_NIS                   6-  15   ///
    int    APRDRG                   16-  19   ///
    byte   APRDRG_Risk_Mortality     20-  21   ///
    byte   APRDRG_Severity           22-  23   ///
    using  "NIS_2016_Severity.ASC"
***  Assign labels to the data elements ***
```

```
label var HOSP_NIS                "NIS hospital number"
label var KEY_NIS                 "NIS record number"
label var APRDRG                  "All Patient Refined DRG"
label var APRDRG_Risk_Mortality    "All Patient Refined DRG: Risk of Mortality Subclass"
label var APRDRG_Severity          "All Patient Refined DRG: Severity of Illness Subclass"
*** Convert special values to missing values ***
recode HOSP_NIS                 (-9999 -8888 -6666=.)
recode KEY_NIS                  (-999999999 -888888888 -666666666=.)
recode APRDRG                   (-999 -888 -666=.)
recode APRDRG_Risk_Mortality     (-9 -8 -6 -5=.)
recode APRDRG_Severity          (-9 -8 -6 -5=.)
save "NIS_2016_Severity.dta", replace
generate copddiag=0
foreach var of varlist I10_DX2 - I10_DX30 {
replace copddiag=1 if substr(`var',1,4)=="J40" || substr(`var',1,4)=="J410" ||
substr(`var',1,4)=="J411" || substr(`var',1,4)=="J418" || substr(`var',1,4)=="J42" ||
substr(`var',1,4)=="J430" || substr(`var',1,4)=="J432" || substr(`var',1,4)=="J438" ||
substr(`var',1,4)=="J439" || substr(`var',1,4)=="J440" || substr(`var',1,4)=="J441" ||
substr(`var',1,4)=="J449"
}
tab copddiag
tab copddiag, missing
* defining inclusion criteria
generate include=0
replace include=1 if  copddiag==1 & AGE>=40 & AMONTH <=11
tab include
sum include, detail
sum AGE, detail
sum LOS, detail
tab DIED
tabulate rural DIED, row
tab agegrp
generate urban=0
replace urban=1 if rural==0
tab urban
tab urban, missing
tab rural, missing
drop if include==0
tab include
generate rural=0
replace rural=1 if PL_NCHS >=5
tab rural
* Generating Elixhauser Comorbidity index variable:
ssc install elixhauser
*ICD10:
elixhauser I10_DX1- I10_DX30, index (10) noshow
```

```
tab elixsum
tab elixsum
describe elixsum
sum elixsum, detail
list elixsum, sep(4)
xtile elixquart = elixsum, nq(4)
list elixsum elixquart, sepby(elixquart)
tab elixquart
sum elixquart
describe elixquart
codebook elixquart
sum elixquart, detail
by DIED: drop if DIED==.
tab DIED, missing
tab DIED rural
sort RACE
by RACE: generate RACEMissing=0
replace RACEMissing=1 if RACE==.
tab RACEMissing
by RACE: generate RACEWHITE=0
replace RACEWHITE=1 if RACE==1
tab RACEWHITE
by RACE: generate RACEBLACK=0
replace RACEBLACK=1 if RACE==2
by RACE: generate RACEHISPANIC=0
replace RACEHISPANIC=1 if RACE==3
by RACE: generate RACEASIANPI=0
replace RACEASIANPI=1 if RACE==4
by RACE: generate RACENATIVEAMERICAN=0
replace RACENATIVEAMERICAN=1 if RACE==5
by RACE: generate RACEOTHER=0
replace RACEOTHER=1 if RACE==6
generate race=0
replace race=1 if  RACEWHITE==1 & RACEBLACK==1 & RACEHISPANIC==1 &
RACEASIANPI==1 & RACENATIVEAMERICAN==1 &RACEOTHER==1 &
RACEMissing==1
generate White=0
replace White=1 if RACEWHITE==1
tab White
generate Black=0
replace Black=1 if RACEBLACK==1
generate Hispanic=0
replace Hispanic=1 if RACEHISPANIC==1
generate AsianPacificIslander=0
replace AsianPacificIslander=1 if RACEASIANPI==1
generate NativeAmerican=0
```

```
replace NativeAmerican=1 if RACENATIVEAMERICAN==1
generate Other=0
replace Other=1 if RACEOTHER==1
generate RACEMiss=0
replace RACEMiss=1 if RACEMissing==1
egen Race = group(White Black Hispanic AsianPacificIslander NativeAmerican Other
RACEMiss)
tab Race
recode race RACEWHITE = 1 RACEBLACK = 2 RACEHISPANIC=3 RACEASIANPI=4
RACENATIVEAMERICAN=5 RACEOTHER=6 RACEMissing=7, gen(Race)
tab race
prop race [pweight=DISCWT]
svy:prop Race
*Table One Agegrp*
tab agegrp
tab agegrp, missing
sort agegrp
by agegrp: drop if agegrp==.
tab agegrp,missing
svy:prop agegrp
*Table One Sex*
tab FEMALE
tab FEMALE, missing
sort FEMALE
by FEMALE: drop if FEMALE==.
tab FEMALE,missing
svy:prop FEMALE
*Table One Payers*
tab PAY1
tab PAY1, missing
sort PAY1
by PAY1: drop if PAY1==.
tab PAY1,missing
svy:prop PAY1
*Table One Urban-Rural*
tab rural
tab rural, missing
sort rural
by rural: drop if rural==.
tab rural,missing
svy:prop rural
*Table One MHI*
sort ZIPINC_QRTL
by ZIPINC_QRTL: generate ZIPINCMissing=0
replace ZIPINCMissing=1 if ZIPINC_QRTL==.
tab ZIPINC_QRTL, missing
```

```
by ZIPINC_QRTL: generate ZIPINC_QRTL1=0
replace ZIPINC_QRTL1=1 if ZIPINC_QRTL==1
tab ZIPINC_QRTL1
by ZIPINC_QRTL: generate ZIPINC_QRTL2=0
replace ZIPINC_QRTL2=1 if ZIPINC_QRTL==2
tab ZIPINC_QRTL2
by ZIPINC_QRTL: generate ZIPINC_QRTL3=0
replace ZIPINC_QRTL3=1 if ZIPINC_QRTL==3
tab ZIPINC_QRTL3
by ZIPINC_QRTL: generate ZIPINC_QRTL4=0
replace ZIPINC_QRTL4=1 if ZIPINC_QRTL==4
tab ZIPINC_QRTL4
generate zipinc=0
replace zipinc=1 if  ZIPINC_QRTL1==1 & ZIPINC_QRTL2==1 & ZIPINC_QRTL3==1 &
ZIPINC_QRTL4==1 & ZIPINCMissing==1
generate CAT1=0
replace CAT1=1 if ZIPINC_QRTL1==1
tab CAT1
generate CAT2=0
replace CAT2=1 if ZIPINC_QRTL2==1
tab CAT2
generate CAT3=0
replace CAT3=1 if ZIPINC_QRTL3==1
tab CAT3
generate CAT4=0
replace CAT4=1 if ZIPINC_QRTL4==1
tab CAT4
generate CAT5=0
replace CAT5=1 if ZIPINCMissing==1
tab CAT5
egen Zipinc = group(CAT1 CAT2 CAT3 CAT4 CAT5)
tab Zipinc
prop Zipinc [pweight=DISCWT]
*Table One Bed Size*
tab HOSP_BEDSIZE
tab HOSP_BEDSIZE, missing
sort HOSP_BEDSIZE
by HOSP_BEDSIZE: drop if HOSP_BEDSIZE==.
tab HOSP_BEDSIZE,missing
svy:prop HOSP_BEDSIZE
*Table One Hospital Region*
tab HOSP_REGION
tab HOSP_REGION, missing
sort HOSP_REGION
by HOSP_REGION: drop if HOSP_REGION==.
tab HOSP_REGION,missing
```

```
svy:prop HOSP_REGION
*Table One LOS*
tab losbin
tab losbin, missing
sort losbin
by losbin: drop if losbin==.
tab losbin,missing
svy:prop losbin
*Table One Hosp Division*
tab HOSP_DIVISION
tab HOSP_DIVISION, missing
sort HOSP_DIVISION
by HOSP_DIVISION: drop if HOSP_REGION==.
tab HOSP_DIVISION,missing
svy:prop HOSP_DIVISION
*Table One CHF*
tab ynel1, missing
svy:prop ynel1
*Table One Cardiac A*
tab ynel2, missing
svy:prop ynel2
*Table One Valv Dis*
tab ynel3, missing
svy:prop ynel3
*Table One PCD*
tab ynel4, missing
svy:prop ynel4
*Table One PVD*
tab ynel5, missing
svy:prop ynel5
*Table One HTN, Uncomp*
tab ynel6, missing
svy:prop ynel6
*Table One Paralysis*
tab ynel7, missing
svy:prop ynel7
*Table One Neuro Dis*
tab ynel8, missing
svy:prop ynel8
*Table One CRD*
tab ynel9, missing
svy:prop ynel9
*Table One Diabetes uncomp*
tab ynel10, missing
svy:prop ynel10
*Table One Diabetes, comp*
```

```
tab ynel11, missing
svy:prop ynel11
*Table One Hypothyroidism*
tab ynel12, missing
svy:prop ynel12
*Table One Renal Failure*
tab ynel13, missing
svy:prop ynel13
*Table One Liver Disease*
tab ynel14, missing
svy:prop ynel14
*Table One Peptic Ulcer*
tab ynel15, missing
svy:prop ynel15
*Table One AIDS/HIV*
tab ynel16, missing
svy:prop ynel16
*Table One Lymphoma*
tab ynel17, missing
svy:prop ynel17
*Table One MCA*
tab ynel18, missing
svy:prop ynel18
*Table One Solid Tumor*
tab ynel19, missing
svy:prop ynel19
*Table One RA*
tab ynel20, missing
svy:prop ynel20
*Table One Coag*
tab ynel21, missing
svy:prop ynel21
*Table One Obesity*
tab ynel22, missing
svy:prop ynel22
*Table One Weight Loss*
tab ynel23, missing
svy:prop ynel23
*Table One Fluid Electrolyte*
tab ynel24, missing
svy:prop ynel24
*Table One Blood Loss Anemia*
tab ynel25, missing
svy:prop ynel25
*Table One Deficiency Anemia*
tab ynel26, missing
```

```
svy:prop ynel26
*Table One Alcohol Abuse*
tab ynel27, missing
svy:prop ynel27
*Table One Drug Abuse*
tab ynel28, missing
svy:prop ynel28
*Table One Psychosis*
tab ynel29, missing
svy:prop ynel29
*Table One Depression*
tab ynel30, missing
svy:prop ynel30
*Table One Hypertension, comp*
tab ynel31, missing
svy:prop ynel31
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): mean AGE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): mean AGE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): mean LOS
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): mean LOS
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion agegrp
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion agegrp
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion FEMALE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion FEMALE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion PAY1
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion PAY1
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(include): proportion rural
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion elixquart
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion elixquart
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion ZIPINC_QRTL
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ZIPINC_QRTL
```

```
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion RACE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion RACE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion HOSP_DIVISION
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion HOSP_DIVISION
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion HOSP_BEDSIZE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion HOSP_BEDSIZE
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion HOSP_REGION
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion HOSP_REGION
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(urban): proportion losbin
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion losbin
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel1
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel2
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel3
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel4
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel5
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel6
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel7
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel8
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel9
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel10
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel11
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel12
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel13
```

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svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel14
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel15
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel16
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel17
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel18
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel19
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel20
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel21
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel22
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel23
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel24
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel25
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel26
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel27
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel28
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel29
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel30
svyset [pweight = DISCWT], strata (NIS_STRATUM) psu (HOSP_NIS)
svy, subpop(rural): proportion ynel31
recode AGE 40/54 = 1 55/64 = 2 65/74=3 75/max=4 , gen(agegrp)
tab agegrp
label value agegrp agelabel
label define agelabel 1 "40-54" 2 "55-64" 3 "65-74" 4 "75+"
tab agegrp
tab FEMALE
label value FEMALE sex
label define sex 0 "Male" 1 "Female"
tab FEMALE
tab HOSP_DIVISION
```

```
label value HOSP_DIVISION division
label define division 1 "New England" 2 "Middle Atlantic" 3 "East North Central" 4 "West North Central" 5 "South Atlantic" 6 "East South Central" 7 "West South Central" 8 "Mountain" 9 "Pacific
tab HOSP_DIVISION
tab PAY1
label value PAY1 payers
label define payers 1 "Medicare" 2 "Medicaid" 3 "Private including HMO" 4 "Self-Pay" 5 "No Charge" 6 "Other"
tab PAY1
tab PL_NCHS
label value PL_NCHS residence
label define residence 1 "Central counties of metro areas of >=1 million population" 2 "Fringe counties of metro areas of >=1 million population" 3 "Counties in metro areas of 250,000-999,999 population" 4 "Counties in metro areas of 50,000-249,999 population" 5 "Micropolitan counties" 6 "Not metropolitan or micropolitan counties"
tab PL_NCHS
tab rural
tab RACE
label value RACE race
label define race 1 "White" 2 "Black" 3 "Hispanic" 4 "Asian or Pacific Islander" 5 "Native American" 6 "Other"
tab RACE
tab ZIPINC_QRTL
label value ZIPINC_QRTL MedianIncome
label define MedianIncome 1 "$1-$42,999" 2 "$43,000-$53,999" 3 "$54,000-$70,999" 4 "$71,000+"
tab ZIPINC_QRTL
tab HOSP_BEDSIZE
label value HOSP_BEDSIZE bedsize
label define bedsize 1 "small" 2 "medium" 3 "large"
tab HOSP_BEDSIZE
tab HOSP_REGION
label value HOSP_REGION region
label define region 1 "Northeast" 2 "Midwest" 3 "South" 4 "West"
tab HOSP_REGION
recode LOS 0/3 = 1 4/max=2 , gen(losbin)
tab losbin
label value losbin loscat
label define loscat 1 "0-3 days" 2 "4+ days"
tab losbin
tab rural DIED
tab copddiag
*chisquare testing*
tabulate ZIPINC_QRTL rural, row nofreq chi2
tabulate ZIPINC_QRTL DIED, row nofreq chi
```

```
tabulate rural DIED, row nofreq chi2
tabulate agegrp rural, row nofreq chi2
tabulate FEMALE rural, row nofreq chi2
tabulate PAY1 rural, row nofreq chi2
tabulate elixquart
*correlation mortality table data*
tabulate FEMALE DIED, row nofreq chi2
by rural, sort: tabulate FEMALE DIED, row nofreq chi2
tabulate RACE DIED, row nofreq chi2
by rural, sort: tabulate RACE DIED, row nofreq chi2
tabulate agegrp DIED, row nofreq chi2
by rural, sort: tabulate agegrp DIED, row nofreq chi2
tabulate ZIPINC_QRTL DIED, row nofreq chi2
by rural, sort: tabulate ZIPINC_QRTL DIED, row nofreq chi2
tabulate losbin DIED, row nofreq chi2
by rural, sort: tabulate losbin DIED, row nofreq chi2
tabulate PAY1 DIED, row nofreq chi2
by rural, sort: tabulate PAY1 DIED, row nofreq chi2
tabulate elixquart DIED, row nofreq chi2
by rural, sort: tabulate elixquart DIED, row nofreq chi2
tabulate HOSP_DIVISION DIED, row nofreq chi2
by rural, sort: tabulate HOSP_DIVISION DIED, row nofreq chi2
tabulate HOSP_REGION DIED, row nofreq chi2
by rural, sort: tabulate HOSP_REGION DIED, row nofreq chi2
tabulate ynel1 DIED, row nofreq chi2
by rural, sort: tabulate ynel1 DIED, row nofreq chi2
tabulate ynel2 DIED, row nofreq chi2
by rural, sort: tabulate ynel2 DIED, row nofreq chi2
tabulate ynel3 DIED, row nofreq chi2
by rural, sort: tabulate ynel3 DIED, row nofreq chi2
tabulate ynel4 DIED, row nofreq chi2
by rural, sort: tabulate ynel4 DIED, row nofreq chi2
tabulate ynel5 DIED, row nofreq chi2
by rural, sort: tabulate ynel5 DIED, row nofreq chi2
tabulate ynel6 DIED, row nofreq chi2
by rural, sort: tabulate ynel6 DIED, row nofreq chi2
tabulate ynel7 DIED, row nofreq chi2
by rural, sort: tabulate ynel7 DIED, row nofreq chi2
tabulate ynel8 DIED, row nofreq chi2
by rural, sort: tabulate ynel8 DIED, row nofreq chi2
tabulate ynel9 DIED, row nofreq chi2
by rural, sort: tabulate ynel9 DIED, row nofreq chi2
tabulate ynel10 DIED, row nofreq chi2
by rural, sort: tabulate ynel10 DIED, row nofreq chi2
tabulate ynel11 DIED, row nofreq chi2
by rural, sort: tabulate ynel11 DIED, row nofreq chi2
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tabulate ynel12 DIED, row nofreq chi2
by rural, sort: tabulate ynel12 DIED, row nofreq chi2
tabulate ynel13 DIED, row nofreq chi2
by rural, sort: tabulate ynel13 DIED, row nofreq chi2
tabulate ynel14 DIED, row nofreq chi2
by rural, sort: tabulate ynel14 DIED, row nofreq chi2
tabulate ynel15 DIED, row nofreq chi2
by rural, sort: tabulate ynel15 DIED, row nofreq chi2
tabulate ynel16 DIED, row nofreq chi2
by rural, sort: tabulate ynel16 DIED, row nofreq chi2
tabulate ynel17 DIED, row nofreq chi2
by rural, sort: tabulate ynel17 DIED, row nofreq chi2
tabulate ynel18 DIED, row nofreq chi2
by rural, sort: tabulate ynel18 DIED, row nofreq chi2
tabulate ynel19 DIED, row nofreq chi2
by rural, sort: tabulate ynel19 DIED, row nofreq chi2
tabulate ynel20 DIED, row nofreq chi2
by rural, sort: tabulate ynel20 DIED, row nofreq chi2
tabulate ynel21 DIED, row nofreq chi2
by rural, sort: tabulate ynel21 DIED, row nofreq chi2
tabulate ynel22 DIED, row nofreq chi2
by rural, sort: tabulate ynel22 DIED, row nofreq chi2
tabulate ynel23 DIED, row nofreq chi2
by rural, sort: tabulate ynel23 DIED, row nofreq chi2
tabulate ynel24 DIED, row nofreq chi2
by rural, sort: tabulate ynel24 DIED, row nofreq chi2
tabulate ynel25 DIED, row nofreq chi2
by rural, sort: tabulate ynel25 DIED, row nofreq chi2
tabulate ynel26 DIED, row nofreq chi2
by rural, sort: tabulate ynel26 DIED, row nofreq chi2
tabulate ynel27 DIED, row nofreq chi2
by rural, sort: tabulate ynel27 DIED, row nofreq chi2
tabulate ynel28 DIED, row nofreq chi2
by rural, sort: tabulate ynel28 DIED, row nofreq chi2
tabulate ynel29 DIED, row nofreq chi2
by rural, sort: tabulate ynel29 DIED, row nofreq chi2
tabulate ynel30 DIED, row nofreq chi2
by rural, sort: tabulate ynel30 DIED, row nofreq chi2
tabulate ynel31 DIED, row nofreq chi2
by rural, sort: tabulate ynel31 DIED, row nofreq chi2
*RURAL versus urban*
*Sex*
logit DIED ib7.Race i.agegrp i.elixquart ib3.HOSP_BEDSIZE i.HOSP_DIVISION ib2.Zipinc
i.PAY1 i.losbin ib1.FEMALE##rural
logit, or
logit DIED ib7.Race i.agegrp i.elixquart ib3.HOSP_BEDSIZE i.HOSP_DIVISION ib2.Zipinc
```

i.PAY1 i.losbin ib1.FEMALE##urban
logit, or
Age Groups
logit DIED ib7.Race i.agegrp i.elixquart ib3.HOSP_BEDSIZE i.HOSP_DIVISION ib2.Zipinc i.PAY1 i.losbin ib1.FEMALE i.agegrp##rural
logit, or
logit DIED ib7.Race i.agegrp i.elixquart ib3.HOSP_BEDSIZE i.HOSP_DIVISION ib2.Zipinc i.PAY1 i.losbin ib1.FEMALE i.agegrp##urban
logit, or
unadjusted OR no interaction
svy:logistic DIED i.agegrp
svy:logistic DIED ib1.FEMALE
svy:logistic DIED i.PAY1
svy:logistic DIED ib2.Zipinc
svy:logistic DIED i.HOSP_BEDSIZE
svy:logistic DIED i.rural
svy:logistic DIED ib7.Race
svy:logistic DIED i.losbin
svy:logistic DIED i.HOSP_DIVISION
svy:logistic DIED i.ynel1 i.ynel2 i.ynel3 i.ynel4 i.ynel5 i.ynel6 i.ynel7 i.ynel8 i.ynel9 i.ynel10 i.ynel11 i.ynel12 i.ynel13 i.ynel14 i.ynel15 i.ynel16 i.ynel17 i.ynel18 i.ynel19 i.ynel20 i.ynel21 i.ynel22 i.ynel23 i.ynel24 i.ynel25 i.ynel26 i.ynel27 i.ynel28 i.ynel29 i.ynel30 i.ynel31
svy:logistic DIED i.ynel2
adjusted OR with Interaction Term
by rural, sort:logistic DIED i.agegrp ib1.FEMALE ib3.HOSP_BEDSIZE i.HOSP_DIVISION i.PAY1 i.losbin ib2.Zipinc ib7.Race
svy:logistic DIED rural##ib7.Race ib2.Zipinc i.agegrp ib1.FEMALE i.HOSP_BEDSIZE i.HOSP_DIVISION i.PAY1 i.losbin
svy:logistic DIED rural##i.HOSP_DIVISION i.agegrp ib1.FEMALE i.HOSP_BEDSIZE ib2.Zipinc i.PAY1 i.losbin ib7.Race
svy:logistic DIED rural##ib1.FEMALE i.HOSP_DIVISION i.agegrp i.HOSP_BEDSIZE ib2.Zipinc i.PAY1 i.losbin ib7.Race
svy:logistic DIED rural##i.HOSP_BEDSIZE ib1.FEMALE i.HOSP_DIVISION i.agegrp ib2.Zipinc i.PAY1 i.losbin ib7.Race i.PAY1 i.losbin
svy:logistic DIED rural##i.losbin i.HOSP_BEDSIZE ib1.FEMALE i.HOSP_DIVISION i.agegrp ib2.Zipinc i.PAY1 i.losbin ib7.Race i.PAY1
svy:logistic DIED rural##ib2.Zipinc i.losbin i.HOSP_BEDSIZE ib1.FEMALE i.HOSP_DIVISION i.agegrp i.PAY1 ib7.Race
svy:logistic DIED rural##i.PAY1 ib2.Zipinc i.losbin i.HOSP_BEDSIZE ib1.FEMALE i.HOSP_DIVISION i.agegrp ib7.Race
by rural, sort:logistic DIED i.ynel1 i.ynel2 i.ynel3 i.ynel4 i.ynel5 i.ynel6 i.ynel7 i.ynel8 i.ynel9 i.ynel10 i.ynel11 i.ynel12 i.ynel13 i.ynel14 i.ynel15 i.ynel16 i.ynel17 i.ynel18 i.ynel19 i.ynel20 i.ynel21 i.ynel22 i.ynel23 i.ynel24 i.ynel25 i.ynel26 i.ynel27 i.ynel28 i.ynel29 i.ynel30 i.ynel31
logistic DIED ynel1##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31

logistic DIED ynel2##rural ynel1 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel3##rural ynel2 ynel1 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel4##rural ynel2 ynel3 ynel1 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel5##rural ynel2 ynel3 ynel4 ynel1 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel6##rural ynel2 ynel3 ynel4 ynel5 ynel1 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel7##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel1 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel8##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel1 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel9##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel1 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel10##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel1 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel11##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel1 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel12##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel1 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel13##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel1 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel14##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel1 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel15##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel1 ynel14 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel16##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel1 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31

logistic DIED ynel17##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel1 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel18##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel1 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel19##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel1 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel20##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel1 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel21##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel1 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel22##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel1 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel23##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel1 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel24##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel1 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel25##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel1 ynel26 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel26##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel1 ynel27 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel27##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel1 ynel28 ynel29 ynel30 ynel31
logistic DIED ynel28##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel1 ynel29 ynel30 ynel31
logistic DIED ynel29##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel1 ynel30 ynel31
logistic DIED ynel30##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel1 ynel31
logistic DIED ynel31##rural ynel2 ynel3 ynel4 ynel5 ynel6 ynel7 ynel8 ynel9 ynel10 ynel11 ynel12 ynel13 ynel14 ynel15 ynel16 ynel17 ynel18 ynel19 ynel20 ynel21 ynel22 ynel23 ynel24 ynel25 ynel26 ynel27 ynel28 ynel29 ynel30 ynel1

STATA Code for Paper Three

Same dataset used for Paper One so load file is under paper one code

```
C:\Users\linabnit\Downloads\2016NRDCostFile.dta
generate TOTCOST= totchg*ccr_nrd
*adjusted for 2023*
generate TCHADJ= TOTCOST*1.26
svyset [pweight = discwt], strata (nrd_stratum) psu (hosp_nrd)
codebook nonmetropolitan agegrp4 female losbin zipinc_qrtl pay1 elixquart TCHADJ
list comorbcondition, sep(4)
xtile quart = comorbcondition, nq(4)
list comorbcondition quart, sepby(quart)
list total_elixcount, sep(4)
xtile elixquart = total_elixcount, nq(4)
list total_elixcount elixquart, sepby(elixquart)
generate TCHADJ1 =.
replace TCHADJ1=TCHADJ if readmit==1
summarize TCHADJ
summarize TCHADJ1
sum TCHADJ1, detail
summarize readmit
tab readmit
mean TCHADJ readmit
tabulate elixquart nonmetropolitan, row
tabulate  elixquart readmit, row
*Labeling categorical variables
label value female sex
label define sex 0 "Male" 1 "Female"
label value losbin los
label define los 0 "0-3 days" 1 "4 days or greater"
label value agegrp4 age1
label define age1 1 "40-54" 2 "55-64" 3 "65-74" 4 "75+"
label value comorbid3 comorbid4
label define comorbid4 0 "0 comorbidities" 1 "1 comorbidity" 2 "2-4 comorbidities" 3 "5+
comorbidities"
label value pay1 payers
label define payers 1 "Medicare" 2 "Medicaid" 3 "Private" 4 "Self-Pay" 5 "No Charge" 6 "Other"
label value hosp_bedsize bedsize
label define bedsize 1 "Small" 2 "Medium" 3 "Large"
label value zipinc_qrtl MedianIncome
label define MedianIncome 1 "$1-$42,999" 2 "$43,000-$53,999" 3 "$54,000-$70,999" 4
"$71,000+"
label value h_contrl ownership
label define ownership 1 "Government" 2 "Private Not for Profit" 3 "Private For Profit"
```

```
label value hosp_urcat4 urbanruralhosp
label define urbanruralhosp 1 "Large Metro" 2 "Small Metro" 3 "Micro" 4 "Nonmetro"
codebook hosp_ur_teach
label value hosp_ur_teach teaching
label define teaching 0 "Metro Non-Teaching" 1 "Metro Teaching" 2 "Non-Metro"
label value comorbcondition comorb
label define comorb 1 "0-4" 2 "5-10" 3 "11-15"
label value readmit readmission
label define readmission 0 "No Readmission" 1 "Readmission"
codebook nonmetropolitan
label value nonmetropolitan urbanrural
label define urbanrural 0 "Metropolitan" 1 "Nonmetropolitan"
codebook elx_grp_1
label value elx_grp_1 CHF
label define CHF 0 "No CHF" 1 "CHF"
codebook elx_grp_2
label value elx_grp_2 CardiacArrhythmias
label define CardiacArrhythmias 0 "No Cardiac Arrhythmias" 1 "Cardiac Arrhythmias"
codebook elx_grp_3
label value elx_grp_3 ValvularDisease
label define ValvularDisease 0 "No Valvular Disease" 1 "Valvular Disease"
codebook elx_grp_4
label value elx_grp_4 PulmCircDisorders
label define PulmCircDisorders 0 "No Pulmonary Circulation Disorders" 1 "Pulmonary
Circulation Disorders"
codebook elx_grp_5
label value elx_grp_5 PerVascDisorders
label define PerVascDisorders 0 "No Peripheral Vascular Disorders" 1 "Peripheral Vascular
Disorders"
codebook elx_grp_6
label value elx_grp_6 HTNUncomp
label define HTNUncomp 0 "No HTN Uncomplicated" 1 "HTN Uncomplicated"
codebook elx_grp_7
label value elx_grp_7 HTNComp
label define HTNComp 0 "No HTN Complicated" 1 "HTN Complicated"
codebook elx_grp_8
label value elx_grp_8 Para
label define Para 0 "No Paralysis" 1 "Paralysis"
codebook elx_grp_9
label value elx_grp_9 OtherNeuro
label define OtherNeuro 0 "No Other Neurological Disorders" 1 "Neurological Disorders"
codebook elx_grp_10
label value elx_grp_10 ChroPulm
label define ChroPulm 0 "No Chronic Pulmonary Disease" 1 "Chronic Pulmonary Disease"
codebook elx_grp_11
label value elx_grp_11 DiabetesUncom
```

```
label define DiabetesUncom 0 "No Diabetes Uncomplicated" 1 "Diabetes Uncomplicated"
codebook elx_grp_12
label value elx_grp_12 DiabetesCom
label define DiabetesCom 0 "No Diabetes Complicated" 1 "Diabetes Complicated"
codebook elx_grp_13
label value elx_grp_13 Hypothy
label define Hypothy 0 "No Hypothyroidism" 1 "Hypothyroidism"
codebook elx_grp_14
label value elx_grp_14 RenalFail
label define RenalFail 0 "No Renal Failure" 1 "Renal Failure"
codebook elx_grp_15
label value elx_grp_15 LiverDis
label define LiverDis 0 "No Liver Disease" 1 "Liver Disease"
codebook elx_grp_16
label value elx_grp_16 PepticUlcer
label define PepticUlcer 0 "No Peptic Ulcer Disease" 1 "Peptic Ulcer Disease"
codebook elx_grp_17
label value elx_grp_17 AIDSHIV
label define AIDSHIV 0 "No AIDS/HIV" 1 "AIDS/HIV"
codebook elx_grp_18
label value elx_grp_18 Lymph
label define Lymph 0 "No Lymphoma" 1 "Lymphoma"
codebook elx_grp_19
label value elx_grp_19 MetaCA
label define MetaCA 0 "No Metastatic Cancer" 1 "Metastatic Cancer"
codebook elx_grp_20
label value elx_grp_20 SolidTU
label define SolidTU 0 "No Solid Tumor without Metastasis" 1 "Solid Tumor without
Metastasis"
codebook elx_grp_21
label value elx_grp_21 RA
label define RA 0 "No Rheumatoid Arthritis/collagen" 1 "Rheumatoid Arthritis/collagen"
codebook elx_grp_22
label value elx_grp_22 Coagulo
label define Coagulo 0 "No Coagulopathy" 1 "Coagulopathy"
codebook elx_grp_23
label value elx_grp_23 Obese
label define Obese 0 "No Obesity" 1 "Obesity"
codebook elx_grp_24
label value elx_grp_24 WeightL
label define WeightL 0 "No Weight Loss" 1 "Weight Loss"
codebook elx_grp_25
label value elx_grp_25 FluidElectrolyte
label define FluidElectrolyte 0 "No Fluid and Electrolyte Disorders" 1 "Fluid and Electrolyte
Disorders"
codebook elx_grp_26
```

```
label value elx_grp_26 BloodlossA
label define BloodlossA 0 "No Blood Loss Anemia" 1 "Blood Loss Anemia"
codebook elx_grp_27
label value elx_grp_27 DeficiencyA
label define DeficiencyA 0 "No Deficiency Anemia" 1 "Deficiency Anemia"
codebook elx_grp_28
label value elx_grp_28 AA
label define AA 0 "No Alcohol Abuse" 1 "Alcohol Abuse"
codebook elx_grp_29
label value elx_grp_29 DA
label define DA 0 "No Drug Abuse" 1 "Drug Abuse"
codebook elx_grp_30
label value elx_grp_30 Psych
label define Psych 0 "No Psychosis" 1 "Psychosis"
codebook elx_grp_31
label value elx_grp_31 Depress
label define Depress 0 "No Depression" 1 "Depression"
*New elixquart variable with dummy variable*
sort zipinc_qrtl
by zipinc_qrtl: generate ZIPINCMissing=0
replace ZIPINCMissing=1 if zipinc_qrtl==.
tab zipinc_qrtl, missing
by zipinc_qrtl: generate ZIPINC_QRTL1=0
replace ZIPINC_QRTL1=1 if zipinc_qrtl==1
tab ZIPINC_QRTL1
by zipinc_qrtl: generate ZIPINC_QRTL2=0
replace ZIPINC_QRTL2=1 if zipinc_qrtl==2
tab ZIPINC_QRTL2
by zipinc_qrtl: generate ZIPINC_QRTL3=0
replace ZIPINC_QRTL3=1 if zipinc_qrtl==3
tab ZIPINC_QRTL3
by zipinc_qrtl: generate ZIPINC_QRTL4=0
replace ZIPINC_QRTL4=1 if zipinc_qrtl==4
tab ZIPINC_QRTL4
generate zipinc=0
replace zipinc=1 if  ZIPINC_QRTL1==1 & ZIPINC_QRTL2==1 & ZIPINC_QRTL3==1 &
ZIPINC_QRTL4==1 & ZIPINCMissing==1
generate CAT1=0
replace CAT1=1 if ZIPINC_QRTL1==1
tab CAT1
generate Cat2=0
replace Cat2=1 if ZIPINC_QRTL2==1
tab Cat2
generate CAT3=0
replace CAT3=1 if ZIPINC_QRTL3==1
tab CAT3
```

```
generate CAT4=0
replace CAT4=1 if ZIPINC_QRTL4==1
tab CAT4
generate CAT5=0
replace CAT5=1 if ZIPINCMissing==1
tab CAT5
egen Zipinc = group(CAT1 Cat2 CAT3 CAT4 CAT5)
tab Zipinc
svy:prop Zipinc
*New table one*
prop Zipinc [pweight=DISCWT]
*Table One Age Groups*
tab agegrp4
tab agegrp4, missing
sort agegrp4
by agegrp4: drop if agegrp4==.
tab agegrp4,missing
svy:prop agegrp4
*Table One Sex*
tab female
tab female, missing
sort female
by female: drop if female==.
tab female,missing
svy:prop female
*Table One LOS*
tab losbin
tab losbin, missing
svy:prop losbin
*Table One Pay1*
tab pay1
tab pay1, missing
sort pay1
by pay1: drop if pay1==.
sort pay1
by pay1: drop if pay1==.a
tab pay1,missing
svy:prop pay1
*Table One Nonmetropilitan*
tab nonmetropolitan
tab nonmetropolitan, missing
sort pay1
by pay1: drop if pay1==.
sort pay1
by pay1: drop if pay1==.a
tab pay1,missing
```

```
svy:prop pay1
*Table One Comorbid*
tab elixquart
tab elixquart, missing
svy:prop elixquart
*Table One Hospital Region*
tab HOSP_REGION
tab HOSP_REGION, missing
sort HOSP_REGION
by HOSP_REGION: drop if HOSP_REGION==.
tab HOSP_REGION,missing
svy:prop HOSP_REGION
*Table One LOS*
tab losbin
tab losbin, missing
sort losbin
by losbin: drop if losbin==.
tab losbin,missing
svy:prop losbin
tab Zipinc
tab zipinc_qrtl
*Table Two Age Group*
*agegrp4*
glm TCHADJ female i.pay1 i.elixquart i.losbin ib2.Zipinc i.agegrp4##i.nonmetropolitan,
family(gam) link(log)
margins agegrp4##nonmetropolitan
*Table Three Age Group*
*agegrp4 readmissions*
glm TCHADJ1 female i.pay1 i.elixquart i.losbin ib2.Zipinc i.agegrp4##i.nonmetropolitan,
family(gam) link(log)
margins agegrp4##nonmetropolitan
*Table Two Sex*
*female*
glm TCHADJ i.pay1 i.elixquart i.losbin ib2.Zipinc i.agegrp4 female##i.nonmetropolitan,
family(gam) link(log)
margins female##nonmetropolitan
*Table Three Sex*
*female readmissions*
glm TCHADJ1 i.pay1 i.elixquart i.losbin ib2.Zipinc i.agegrp4 female##i.nonmetropolitan,
family(gam) link(log)
margins female##nonmetropolitan
*Table Two LOS*
*losbin*
glm TCHADJ i.pay1 i.elixquart ib2.Zipinc i.agegrp4 female i.losbin##i.nonmetropolitan,
family(gam) link(log)
margins losbin##nonmetropolitan
```

```
*Table Three LOS*
*losbin readmissions*
glm TCHADJ1 i.pay1 i.elixquart ib2.Zipinc i.agegrp4 female i.losbin##i.nonmetropolitan,
family(gam) link(log)
margins losbin##nonmetropolitan
*Table Two PAY*
*pay1*
glm TCHADJ i.elixquart ib2.Zipinc i.agegrp4 female i.losbin i.pay1##i.nonmetropolitan,
family(gam) link(log)
margins pay1##nonmetropolitan
*Table Three PAY*
*pay1 readmissions*
glm TCHADJ1 i.elixquart ib2.Zipinc i.agegrp4 female i.losbin i.pay1##i.nonmetropolitan,
family(gam) link(log)
margins pay1##nonmetropolitan
*Table Two zipinc*
*Zipinc*
glm TCHADJ i.elixquart i.agegrp4 female i.losbin i.pay1 ib2.Zipinc##i.nonmetropolitan,
family(gam) link(log)
margins Zipinc##nonmetropolitan
*Table Three zipinc*
*Zipinc readmissions*
glm TCHADJ1 i.elixquart i.agegrp4 female i.losbin i.pay1 ib2.Zipinc##i.nonmetropolitan,
family(gam) link(log)
margins Zipinc##nonmetropolitan
*Table Two comorbid*
*elixquart*
glm TCHADJ i.agegrp4 female i.losbin i.pay1 ib2.Zipinc i.elixquart##i.nonmetropolitan,
family(gam) link(log)
margins elixquart##nonmetropolitan
*Table Three comorbid*
*elixquart readmissions*
glm TCHADJ1 i.agegrp4 female i.losbin i.pay1 ib2.Zipinc i.elixquart##i.nonmetropolitan,
family(gam) link(log)
margins elixquart##nonmetropolitan
*Tables 4 and 5*
*CHF*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_1##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_1##nonmetropolitan
*CHF Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_1##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_1##nonmetropolitan
*Cardiac Arrhythmia*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_2##i.nonmetropolitan,
```

```
family(gam) link(log)
margins elx_grp_2##nonmetropolitan
*Cardiac Arrhythmia Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_2##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_2##nonmetropolitan
*Valvular Disease*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_3##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_3##nonmetropolitan
*Valvular Disease Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_3##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_3##nonmetropolitan
*Pulmonary Circulation Disorders*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_4##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_4##nonmetropolitan
*Pulmonary Circulation Disorders Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_4##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_4##nonmetropolitan
*Peripheral Vascular Disorders*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_5##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_5##nonmetropolitan
*Peripheral Vascular Disorders Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_5##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_5##nonmetropolitan
*Hypertension, Uncomplicated*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_6##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_6##nonmetropolitan
*Hypertension, Uncomplicated Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_6##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_6##nonmetropolitan
*Hypertension, Complicated*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_7##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_7##nonmetropolitan
*Hypertension, Complicated Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_7##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_7##nonmetropolitan
```

```
*Paralysis*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_8##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_8##nonmetropolitan
*Paralysis Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_8##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_8##nonmetropolitan
*Neurological Disorders*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_9##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_9##nonmetropolitan
*Neurological Disorders Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_9##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_9##nonmetropolitan
*Chronic Pulmonary Disease*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_10##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_10##nonmetropolitan
*Chronic Pulmonary Disease Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_10##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_10##nonmetropolitan
*Diabetes, Uncomplicated*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_11##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_11##nonmetropolitan
*Diabetes, Uncomplicated Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_11##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_11##nonmetropolitan
*Diabetes, Complicated*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_12##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_12##nonmetropolitan
*Diabetes, Complicated Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_12##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_12##nonmetropolitan
*Hypothyroidism*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_13##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_13##nonmetropolitan
*Hypothyroidism readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_13##i.nonmetropolitan,
```

```
family(gam) link(log)
margins elx_grp_13##nonmetropolitan
*Renal Failure*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_14##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_14##nonmetropolitan
*Renal Failure Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_14##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_14##nonmetropolitan
*Liver Disease*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_15##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_15##nonmetropolitan
*Liver Disease Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_15##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_15##nonmetropolitan
*Peptic Ulcer Disease*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_16##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_16##nonmetropolitan
*Peptic Ulcer Disease Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_16##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_16##nonmetropolitan
*AIDS/HIV*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_17##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_17##nonmetropolitan
*AIDS/HIV Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_17##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_17##nonmetropolitan
*Lymphoma*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_18##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_18##nonmetropolitan
*Lymphoma Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_18##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_18##nonmetropolitan
*Metastatic CA*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_19##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_19##nonmetropolitan
```

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*Metastatic CA Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_19##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_19##nonmetropolitan
*Solid Tumor*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_20##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_20##nonmetropolitan
*Solid Tumor Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_20##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_20##nonmetropolitan
*Rheumatoid*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_21##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_21##nonmetropolitan
*Rheumatoid Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_21##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_21##nonmetropolitan
*Coagulopathy*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_22##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_22##nonmetropolitan
*Coagulopathy Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_22##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_22##nonmetropolitan
*Obesity*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_23##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_23##nonmetropolitan
*Obesity Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_23##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_23##nonmetropolitan
*Weight Loss*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_24##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_24##nonmetropolitan
*Weight Loss Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_24##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_24##nonmetropolitan
*Fluid and Electrolyte*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_25##i.nonmetropolitan,
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```
family(gam) link(log)
margins elx_grp_25##nonmetropolitan
*Fluid and Electrolyte Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_25##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_25##nonmetropolitan
*Blood Loss Anemia*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_26##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_26##nonmetropolitan
*Blood Loss Anemia Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_26##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_26##nonmetropolitan
*Deficiency Anemia*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_27##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_27##nonmetropolitan
*Deficiency Anemia Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_27##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_27##nonmetropolitan
*Alcohol Abuse*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_28##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_28##nonmetropolitan
*Alcohol Abuse Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_28##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_28##nonmetropolitan
*Drug Abuse*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_29##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_29##nonmetropolitan
*Drug Abuse Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_29##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_29##nonmetropolitan
*Psychosis*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_30##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_30##nonmetropolitan
*Psychosis Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_30##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_30##nonmetropolitan
```

```
*Depression*
glm TCHADJ female i.pay1 i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_31##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_31##nonmetropolitan
*Depression Readmission*
glm TCHADJ1 female i.pay1  i.losbin ib2.Zipinc i.agegrp4 i.elx_grp_31##i.nonmetropolitan,
family(gam) link(log)
margins elx_grp_31##nonmetropolitan
```