RURAL MEDICARE BENEFICIARIES AND FREQUENT EMERGENCY DEPARTMENT USERS

A Dissertation

by

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ABSTRACT

This dissertation presents three research studies aimed at understanding the healthcare of rural Medicare beneficiaries. The literature has described the health of rural residents, when compared to their urban counterparts, as poorer, sicker and with less access to healthcare. Thus, the purpose of this study was to measure changes between definitions of rurality, characterize the demographics of rural Medicare beneficiaries, identify the main reasons for emergency department (ED) utilization, and analyze rural beneficiaries' patterns of ED use. These studies will fill a gap in the literature as there is no published research on this topic using 100% of Medicare enrollment data. This analysis was conducted using 2018 data Medicare data. These studies employed descriptive statistics, sensitivity testing, and logistic regression analyses.

The results showed that, when compared to urban beneficiaries, rural beneficiaries were mostly white, women, age of 18-84, had a higher proportion of persons with disabled status, and had lower proportions of the oldest patients (85+). When comparing definitions of rurality, the Rural Urban Commuting Area (RUCA) codes assigned the largest number of beneficiaries as rural dwelling. Of all rural FFS Medicare enrollees, 23% used the emergency department at least once in 2018. Of those who used the ED, most only used the ED once. Among beneficiaries who used the ED, 14% returned to the emergency department four or more times (frequent ED users). Among the top reasons for ED use were chronic conditions related to heart and pulmonary diseases; symptoms of chronic conditions such as infection or inflammation;

and issues related to falls such as syncope, collapse, and head injury. Finally, patterns of ED utilization were not affected by level of rurality.

The results from this research suggest that, given the choice of rural classifications system to use, states would benefit most (have higher counts of rural beneficiaries) by using the RUCA codes. Rural Medicare beneficiaries who used ED services had a legitimate need to seek care outside of their local areas. Thus, by understanding the needs and utilization patterns of ED use for rural populations, healthcare systems can adapt to provide services vital to their communities.

DEDICATION

I dedicate this to my children, Aram and Aalok, who gave me the fire to survive and continue until the end.

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Many thanks to my community, mentors, friends, and colleagues who supported me in so many ways. I thank them for baby-sitting, reading through my dissertation, listening to my presentations over and over, and cheering me on even when they did not understand my work. They generously gave of their time and knowledge selflessly to see me reach this goal.

I thank my children, Aram and Aalok, who sat with me while I worked, patiently waited until I could play with them, and gave me the love I needed to accomplish my goals. A big thanks to my husband, Iggy, for helping me stay focused at the end of this journey.

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NOMENCLATURE

AIAN	American Indian/Alaska Native
API	Asian/Pacific Islander
AIC	Akaike Information Criterion
CDC	Centers for Disease Control
COPD	Chronic Obstructive Pulmonary Disease
CMS	Centers for Medicare & Medicaid Services
CBSA	Core-Based Statistical Area
DRG	Diagnosis-Related Group
ED	Emergency Department
ERS	Economic Research Service
FIPS	Federal Information Processing System
FFS	Fee-for-service
FORHP	Federal Office of Rural Health Policy
GOF	Goodness-of-Fit
HHS	United States Department of Health & Human Services
ICD-10	International Classification of Diseases, Tenth Revision
IRB	Institutional Review Board
MA	Medicare Advantage
MedPAC	Medicare Payment Advisory Commission
OMB	Office of Management and Budget

ResDAC	Research Data Assistance Center
RUCA	Rural-Urban Commuting Area
UIC	Urban Influence Codes
US	United States of America
USDA	United States Department of Agriculture
VRDC	Virtual Research Data Center
ZIP	Zone Improvement Area

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

CHAPTER I

INTRODUCTION

Background

Rural areas comprise a significant part of the United States (US), with more than 46 million people and close to 25% of Medicare beneficiaries residing in areas designated as rural.[1-4] The literature has described the health of residents of rural communities, when compared to their urban counterparts, as poorer, sicker and with less access to healthcare.[5-7] Despite opposing perspectives that frequently divide the U.S. political system, there is currently bipartisan interest in addressing health disparities for rural populations that has been made a priority for federal agencies such as the United States Department of Health & Human Services (HHS), and the Centers for Medicare & Medicaid Services (CMS).[4,8] On August 11th, 2020, CMS announced it is leading the most current push for rural healthcare reform through the implementation of the Community Health Access and Rural Transformation (CHART) Model which tests funding for rural health care systems and provides flexibilities to rural healthcare providers.[9]

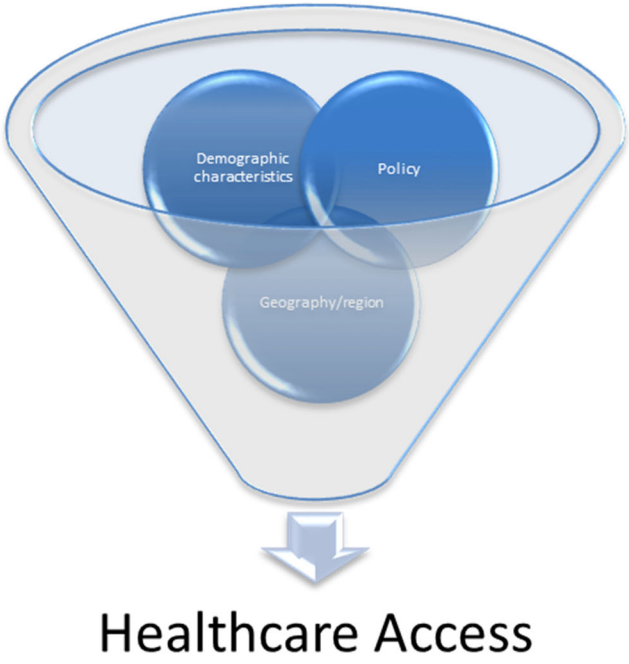
Although there is heightened interest in improving rural health, definitions of "rurality" are inconsistent across agencies.[10,11] Within the federal government, at least 17 different definitions of rurality are used to guide policies for funding grants, research, and health services.[12-15] The purpose of this study was to measure the differences that occur when policy ascribes different definitions of rurality, characterize the demographics of rural Medicare beneficiaries, identify the main reasons for emergency

department (ED) utilization by beneficiaries in rural areas, and analyze rural beneficiaries' patterns of ED use. This will fill a gap in the literature as there is no published research that has studied this topic using 100 % of Medicare enrollment data.[16-18]

Theoretical Framework

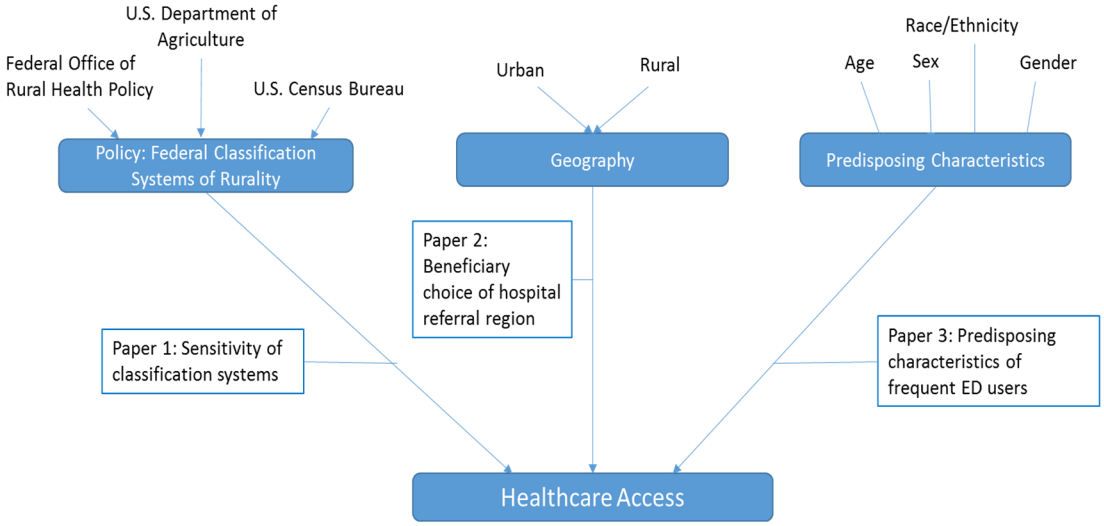
Anderson and Aday address healthcare utilization for rural communities through their Framework for the Study of Access to Healthcare.[19-20] This framework posits that access to healthcare is based on overlapping variables of individual demographic characteristics, the need for care, and socio-demographic characteristics such as place of residence. These characteristics may either increase access to healthcare or further limit access to it. Figure 1 depicts the elements used to frame this research.

Figure 1 Framework for the Study of Access (adapted from Aday and Anderson, 1974)



Through this research, I first analyzed the differences that occurred when applying 4 different classification systems of rurality to Medicare beneficiary enrollment data and characterized the beneficiaries that compose the rural Medicare population. Secondly, this analysis studied the predisposing characteristics and chronic conditions associated with high ED utilization (≥4 ED visits per year) for rural dwelling Medicare beneficiaries. Lastly, I identified patterns of ED utilization through the use of hospital markets. This allows for policy and health interventions to identify gaps in healthcare needs of rural Medicare beneficiaries and provide support for a more efficient use of health services. Figure 2 illustrates how this research addressed facets from Anderson and Aday's Framework for the Study of Access to Healthcare. [19-20]

Figure 2 Healthcare Framework Adapted from the Study of Access to Healthcare

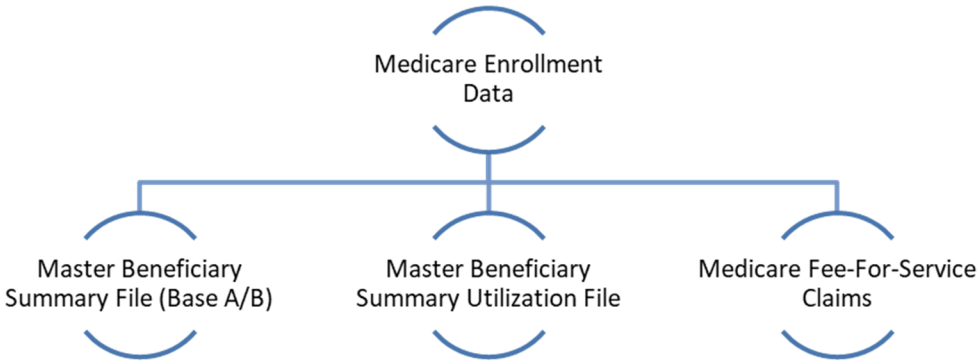


Data Source

This analysis was conducted using Medicare beneficiary enrollment data for the year 2018.[21] Research question 1 drew from the Medicare enrollment database while research questions 2 and 3 required the merged beneficiary enrollment file, chronic

conditions files, and the Medicare fee-for-services claims files using a unique beneficiary identifier to link the demographics, health, and utilization information. Figure 3 lists the datasets that were used for this analysis.

Figure 3 Data Files

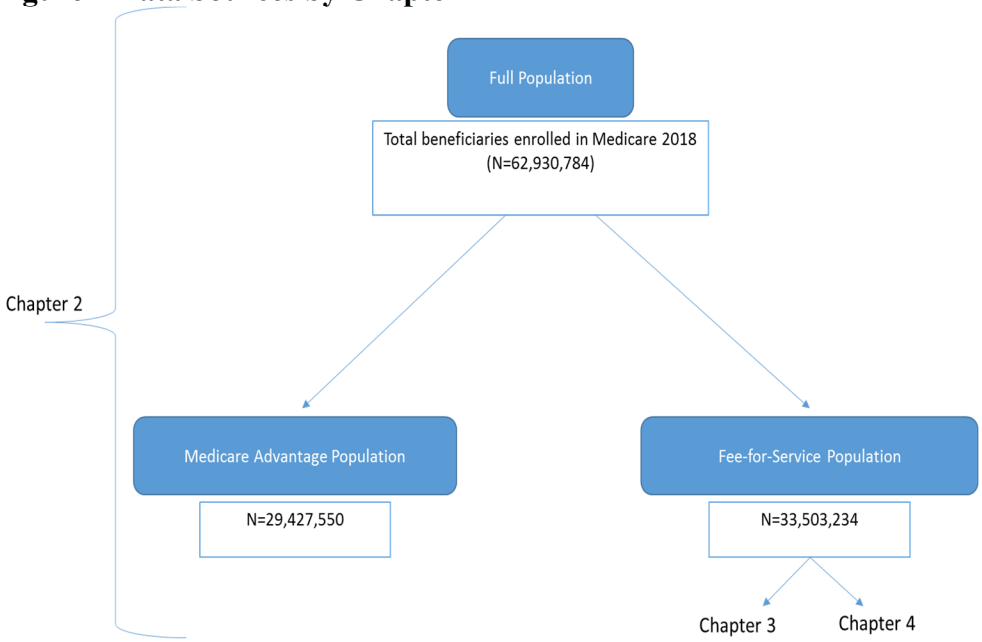


All datasets were housed through the Virtual Research Data Center (VRDC), which provided a secure and protected environment within CMS.[22] Accessing the data through the VRDC satisfied all CMS and Texas A&M Institutional Review Board (IRB) privacy and security requirements. This research was approved through the Texas A&M IRB 2019-0853D.

Chapter II (paper 1) used the full population of the Medicare enrolled beneficiaries (N=62,930,784), while Chapter III (paper 2) and Chapter IV (paper 3) were limited to those fully covered by Medicare A and B fee-for-service (FFS) to ensure that the analysis was grounded on complete and comparable data.[22] CMS does not collect claims and utilization data for beneficiaries enrolled in Medicare Advantage

(MA), a health plan offered by a private company that contracts with Medicare to provide Part A and Part B benefits.[3] Over half of Medicare beneficiaries (n=33,503,234) were considered FFS. Figure 4 illustrates the datasets used for each Chapters II through IV.

Figure 4 Data Sources by Chapter



When comparing the MA and FFS beneficiary populations, there were differences in demographic characteristics. The FFS population had more of the older beneficiaries, similar percentages by gender, and had a less diverse population of racial and ethnic minority groups when compared to the MA population. FFS had a higher proportion of white beneficiaries by more than a 12% difference. Table 1 lists the characteristics of the FFS and MA populations in more detail.

Table 1 Medicare Beneficiary Demographics by Fee-for-Services and Medicare Advantage

N=62,930,784 Characteristic	Fee-for-Service (N=33,503,234)	Medicare Advantage (N=29,427,550)
Age		
0-17	<0.1	<0.1
18-64	15.2	13.8
65-74	45.9	52.4
75-84	26.3	24.2
85+	12.6	9.6
Total	100.0	100.0
Sex		
Male	45.3	46.3
Female	54.7	53.7
Race/Ethnicity		
White	79.4	67.3
Black	9.0	12.2
Hispanic	5.9	13.4
API	2.6	4.2
AIAN	0.6	0.3
Unknown	2.5	2.6
Disabled Status	23.1	22.7

Conclusion

Rural hospitals are often the largest local employer for rural communities and provide critical access care to life-saving services.[23-24] Yet, rural hospitals are closing to due to lack of financial solvency that is likely due to inefficiencies in the healthcare system.[25-26] This creates growing healthcare disparities for rural populations.[26-28] Moreover, emergency care is a costly services as the highest financial burden is created by a small number of patients that return to the ED 4 or more times a year.[29-30] This research will inform policy, federal agencies, and hospital systems on the needs of rural populations that rely on local hospital emergency services for life-saving care. By

understanding the needs and utilization patterns of ED use for rural populations, healthcare systems can adapt to provide services vital to their communities.

CHAPTER II

PRACTICAL IMPLICATIONS OF USING DIFFERENT RURAL CLASSIFICATION SYSTEMS IN MEDICARE DATA

Introduction and Background

The federal government uses more than 17 different classification systems of rurality to inform policy on grant allocations, funds for infrastructure, and adjustments for health services payments.[31-35] These varying methodologies for defining rurality and its populations may carry implications for sustainability of rural hospitals, as provider payments may be adjusted by 17% if services were rendered in a rural area. Scholars have described rural populations as older, poorer, sicker, at an increased risk of early death, and having less access to healthcare than people living in non-rural areas.[4,6,28,36-37] It is, therefore, important to identify rural populations and demographic characteristics to address health disparities in rural areas.

This analysis measured the differences that occur across four classification systems of rurality on Medicare enrollment data for the year 2018. The four systems used were: 1) The US Census Bureau developed Core Based Statistical Area (CBSA) codes, 2) The United States Department of Agriculture's (USDA) Urban Influence Codes (UIC), and 3) Rural-Urban Commuting Area (RUCA) codes, and 4) The Federal Office of Rural Health Policy's (FORHP) rural eligible ZIP codes. The four federal classification systems compared were selected based on the literature related to rural

health in health services research along with the feasibility to merge the system with Medicare data.[38-39]

Table 2 lists each classification system's definition of rurality and examples of how each definition has been used in healthcare. Rurality across all classification systems was defined as all categories considered non-metropolitan areas. For this analysis, rural and non-metropolitan were interchangeable terms.

Table 2 Rural Classification Systems and their uses in Healthcare

Classification System	Unit of Measurement	Criteria for Rural Assignation	Uses in Healthcare
US Census Bureau Core-Based Statistical Areas (CBSA)	County level: 1) Metropolitan 2) Micropolitan 3) Non-CBSA	All non-metropolitan areas (Micropolitan and Non-CBSA)	Inpatient prospective systems, wage index adjustments, and rural adjustment for healthcare services
U.S. Department of Agriculture (USDA) Urban Influence Codes (UIC)	County level: Subdivided into 2 metro (1-2) categories and 10 non-metro categories (3-12), resulting in a 12-part county classification	All non-metropolitan areas (codes 3-12)	Medicare Payment Advisory Commission (MedPAC) for urban or rural reports
USDA Rural-Urban Commuting Areas (RUCA)	ZIP code level: Whole numbers (1-3) delineate metropolitan areas, (4-8) micropolitan, (9) small town, and (10) rural commuting areas	Primary RUCA codes 4 through 10 (Micropolitan Area Core, population up to 49,999)	Used in the FORHP eligible areas, healthcare related grants, and social diversity
Federal Office of Rural Health Policy (FORHP) Eligible ZIP Codes	ZIP code level: Using County and census tracts 1) Rural 2) Non-rural	All non-metropolitan areas using RUCA codes 4 through 10, and FORHP identified census tracts	Critical access hospital determination, telehealth billing, and healthcare related grants

To date, the literature has predominantly used Medicare population samples, populations limited to certain states, and Veterans Affairs sample data to inform policy; this limits the generalizability of the findings.[40-41] Given the potential implications the definitions of rurality may have on federally supported health services, the recent literature has called for a comparative analysis on rural classification systems using

Medicare data.[13] This timely analysis investigating the sensitivity of classification systems across demographic characteristics of Medicare beneficiary data fills this gap in the literature. Through this analysis, I also described the demographic characteristics of rural Medicare beneficiaries.

Research Questions

1: What are the characteristics of rural Medicare beneficiaries?

2: How do beneficiary characteristics differ when comparing four different federal classification systems of rurality?

Hypothesis

The four geographic classification systems used in this analysis will produce results in line with prior literature and the US Census. The proportion of rurality for each definition should range from 18% to 20%. The characteristics of rural Medicare beneficiaries should reflect being older, sicker, and less ethnically and racially diverse than their urban counterparts.

Methodology

Data Sources

Data were analyzed using SAS version 9.4. I employed 100% of national Medicare enrollment data for the year 2018 with a total of 62,930,784 beneficiaries. Beneficiaries included in this dataset were enrolled from January 1, 2018 through December 31, 2018. I excluded beneficiaries residing in Puerto Rico and other U.S. territories, leaving 62,123,723 beneficiaries living in Washington, D.C. and all 50 states in the analytic sample. This dataset included CBSA codes to identify counties as

metropolitan (population greater than 50,000), micropolitan (population between 10,000 and 50,000), or non-core based statistical area (population less than 10,000). The CBSA classification system was created by the US Census Bureau; it is the first of the four definitions used for this analysis.[21,42] There were 945 CBSA codes, each consisting of one or more counties containing an urban core.[22] In order to be more inclusive of rural areas and following the methodology of CMS, Census, and USDA, all non-metropolitan areas (both micropolitan and non-CBSA) were classified as rural.[43-44]

The USDA population-based classification system known as the UIC, had twelve categories for counties assigned as metropolitan and non-metropolitan. Codes 1 and 2 were considered metropolitan, while codes 3 through 12 were classified as non-metropolitan areas. Table 3 provides a brief description of the 12 UIC codes. The UIC codes were merged to the enrollment dataset by county Federal Information Processing System (FIPS) code resulting in missing values for 2,116 beneficiaries.[45]

Table 3 Urban Influence Codes

Metropolitan counties	
1	In large metro area of 1+ million residents
2	In small metro area of less than 1 million residents
Nonmetropolitan counties	
3	Micropolitan area adjacent to large metro area
4	Noncore adjacent to large metro area
5	Micropolitan area adjacent to small metro area
6	Noncore adjacent to small metro area and contains a town of at least 2,500 residents
7	Noncore adjacent to small metro area and does not contain a town of at least 2,500 residents
8	Micropolitan area not adjacent to a metro area
9	Noncore adjacent to micro area and contains a town of at least 2,500 residents
10	Noncore adjacent to micro area and does not contain a town of at least 2,500 residents
11	Noncore not adjacent to metro or micro area and contains a town of at least 2,500 residents
12	Noncore not adjacent to metro or micro area and does not contain a town of at least 2,500 residents

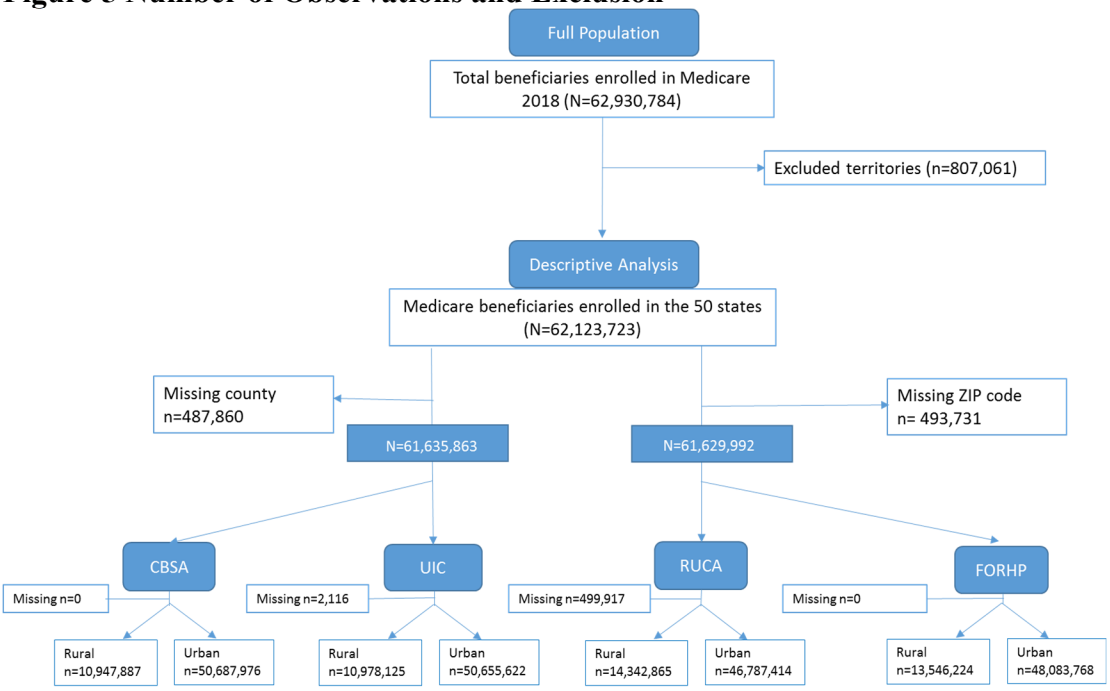
The RUCA codes used 10 levels to identify counties as metropolitan, micropolitan, small town, and rural commuting areas. Table 4 lists the RUCA codes and each code's definition and a brief description of the ten RUCA codes. RUCA codes 4 through 10 (all non-metropolitan/non-urban areas) were classified as rural.[46] The RUCA codes were merged to the enrollment dataset by zone improvement plan (ZIP) code resulting in missing RUCA codes for 499,917 Medicare beneficiaries due to an incomplete linking file.

Table 4 Rural-Urban Commuting Area Codes

1	Metropolitan area core: primary flow within an urbanized area (UA)
2	Metropolitan area high commuting: primary flow 30% or more to a UA
3	Metropolitan area low commuting: primary flow 10% to 30% to a UA
4	Micropolitan area core: primary flow within an urban cluster of 10,000 to 4 (large urban core)
5	Micropolitan high commuting: primary flow 30% or more to a large urban
6	Micropolitan low commuting: primary flow 10% to 30% to a large UC
7	Small town core: primary flow within an urban cluster of 2,500 to 9,999 (s
8	Small town high commuting: primary flow 30% or more to a small UC
9	Small town low commuting: primary flow 10% to 30% to a small UC
10	Rural areas: primary flow to a tract outside a UA or UC

The Federal Office of Rural Health Policy (FORHP) provides a public use file that identifies ZIP codes considered rural, with a total of 18,776 ZIP codes.[12] The FORHP eligibility ZIP code file was merged to the Medicare beneficiary enrollment file resulting in zero missing values for beneficiary ZIP code. Figure 5 depicts the number of observations for each definition dataset and how they were derived.

Figure 5 Number of Observations and Exclusion



Variables

I compared the demographic characteristics of age, sex, race and ethnicity, disability status, and enrollment type (Medicare part A, B, D, or Medicare Advantage) across the four classification systems. Age was a continuous variable transformed into categories (in years: 0-18, 19-64, 65-74, 78-84, and 85+) to offer more meaningful conclusions. Sex was a dichotomous variable that provided the gender of a beneficiary as male or female. Due to the outdated collection methods and missingness of race and ethnicity for Medicare enrollment data[47], race and ethnicity was imputed using an algorithm developed by the Research Triangle Institute (RTI).[48] This provided the following categories of race and ethnicity in Medicare data: unknown, white (non-Hispanic), Black or African-American, Asian or Pacific Islander, Hispanic, and American Indian or Alaska Native.[48] Medicare beneficiaries were identified as dual

eligible if they qualified for both Medicare and full or partial Medicaid benefits , which include beneficiaries enrolled in Specified Low Income Medicare Beneficiary program (SLMB) and Qualified Medicare Beneficiary (QMB).[49] To identify vulnerable populations, disability status was also included in this analysis. Disability status was defined through the original reason for Medicare entitlement.[45]

Analyses

After cleaning the data through formatting of variables, removing duplicates, and collapsing and merging datasets to achieve the most accurate and concise database, I analyzed all variables for frequency, missingness, and percentages. For each of the classification systems of rurality, I first ran a descriptive analysis of Medicare beneficiary demographics, enrollment, and disability status. I then tested the definitions for sensitivity by comparing each classification system against the enrollment data and measuring the number of beneficiaries that "switched" geographic assignation from one definition to another (at the beneficiary level). This provided a set of six comparisons to measure change: 1) CBSA to UIC, 2) CBSA to RUCA, 3) CBSA to FORHP, 4) UIC to RUCA, 5) UIC to FORHP, and 6) RUCA to FORHP. I assigned the direction of change (urban to rural or rural to urban) for each of the comparison groups to determine the extent of stability or change of the definitions.

At the state level, Medicare beneficiary enrollment was calculated for each state and summarized as percentages by geography for each of the classification systems. I then summarized the percentage change in geographic assignation by state for each of

the six comparison groups to evaluate which states would have the largest differences by a change in definition.

Results

Medicare Descriptive Analysis

Rural proportions of Medicare beneficiaries ranged from 17.8% for UIC and CBSA to 23.5% for RUCA. RUCA counted the largest percentage and number of rural beneficiaries. Table 5 depicts the percentage of beneficiaries by geography for each of the geographic classification systems.

Table 5 Classification Systems by Geography

Classification System	Rural		Urban		Total by System
	N	%	N	%	
CBSA	10,947,887	17.8	50,687,976	82.2	61,635,863
UIC	10,978,125	17.8	50,655,622	82.2	61,633,747
RUCA	14,342,865	23.5	46,787,210	76.5	61,130,075
FORHP	13,546,224	22.0	48,083,768	78.0	61,629,992

For both rural and urban areas, most Medicare beneficiaries were (~50%) age 65-74, followed by about 25% of beneficiaries age 75-85. Rural and urban areas were also similar throughout all classification systems where more than 50% of Medicare beneficiaries were women. All classification systems showed rural areas had a lower percentage of the beneficiaries age 85 and over. Throughout all four systems, rural areas were consistently comprised of higher percentages (~14% greater) of white Medicare beneficiaries than urban areas. Urban areas had higher proportions of racial and ethnic minority groups, with the exceptions of AIAN, when compared to rural areas. Rural

areas had higher proportions of people with disabilities and dual eligible than urban areas regardless of classification system used.

Except for unknown race, by a difference of less than 0.1%, CBSA and UIC results were identical at the national level for beneficiary characteristics and enrollment data across classification systems. There was more variation when comparing RUCA and FORHP classifications for race and ethnicity, than when comparing CBSA and UIC. The largest difference between definitions of rurality at the ZIP code level (RUCA and FORHP) was of 0.4%. Table 6 displays the characteristics of Medicare beneficiaries by geography and classification system.

Table 6 Medicare Beneficiary Characteristics by Geography and Classification System

Characteristics	CBSA		UIC		RUCA		FORHP	
Age	**Rural %**	**Urban %**	**Rural %**	**Urban %**	**Rural %**	**Urban %**	**Rural %**	**Urban %**
0-17	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
18-64	16.9	14.0	16.9	14.0	16.6	13.9	16.6	13.9
65-74	47.6	49.4	47.6	49.4	47.8	49.4	47.9	49.4
75-84	25.2	25.3	25.2	25.3	25.3	25.3	25.3	25.3
85+	10.3	11.3	10.3	11.3	10.3	11.4	10.3	11.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Sex								
Male	47.4	45.4	47.4	45.4	47.2	45.3	47.3	45.3
Female	52.7	54.6	52.7	54.6	52.8	54.7	52.7	54.7
Race/Ethnicity								
White	86.8	72.3	86.8	72.3	86.1	71.4	86.5	71.6
Black	6.7	11.5	6.7	11.5	6.8	11.9	6.5	11.9
Hispanic	3.0	9.3	3.0	9.3	3.6	9.5	3.4	9.5
API	0.6	4.0	0.6	4.0	0.7	4.2	0.6	4.1
AIAN	1.2	0.3	1.2	0.3	1.1	0.3	1.2	0.2
Unknown	1.8	2.7	1.7	2.7	1.8	2.8	1.8	2.8
Disabled Status	27.4	21.8	27.4	21.8	26.9	21.6	26.9	21.7

When looking at enrollment data, rural areas showed smaller proportions of MA enrollees than urban areas regardless of system used for assigning rurality. Table 7 lists Medicare enrollment type by geography and classification system. CBSA and UIC classification systems provided nearly matching results with differences that were less than 0.1 %, while RUCA and FORHP had larger variations, with the largest difference being less than 0.3%. Appendix A provides a detailed comparison of descriptive statistics by classification and by geography.

Table 7 Medicare Beneficiary Enrollment by Geography and Classification System

Coverage Type	CBSA		UIC		RUCA		FORHP	
	Rural %	Urban %	Rural %	Urban %	Rural %	Urban %	Rural %	Urban %
Part A	99.7	99.4	99.7	99.4	99.7	99.3	99.7	99.3
Part B	94.1	91.8	94.1	91.8	94.1	91.7	94.0	91.7
Part C	26.3	38.2	26.3	38.2	27.9	38.6	27.6	38.5
Part D	73.6	75.1	73.6	75.1	73.8	75.2	73.7	75.2
Dually Eligible	20.5	19.6	20.5	19.6	20.2	19.7	20.2	19.7

Sensitivity Analysis of Classification Systems Using Medicare Data

Sensitivity at Beneficiary Level

At the beneficiary level, the largest changes in geographic classification occurred when switching from RUCA codes to UIC or CBSA. Changing RUCA to either UIC or CBSA resulted in 6.5% of beneficiaries originally classified as rural residents to being classified as urban residents. Changes in the direction from urban to rural classification ranged from 0.0% to 4.4%. The most stable relationship among the systems was between the UIC and CBSA codes, with the amount of change ranging from 0 to 0.1%. Table 8 lists the sensitivity of the definitions when measuring change across classification systems using Medicare enrollment data.

Table 8 Medicare Beneficiary Changes and Stability by Classification System

	Changed				Stable			
	Urban to Rural		Rural to Urban		Remained Urban		Remained Rural	
Definitions	N	% Change	N	% Change	N	% Stable	N	% Stable
RUCA vs. UIC	628,538	1.0	4,010,716	6.5	46,158,591	74.3	10,330,252	16.6
RUCA vs. CBSA	628,571	1.0	4,043,018	6.5	46,158,639	74.3	10,299,847	16.6
RUCA vs. FORHP	961,970	1.6	1,791,100	2.9	45,825,240	73.8	12,551,765	20.2
UIC vs. CBSA	-	0.0	32,346	0.1	50,655,622	81.5	10,945,779	17.6
UIC vs. FORHP	2,680,173	4.3	113,038	0.2	47,961,556	77.2	10,864,079	17.5
CBSA vs. FORHP	2,712,476	4.4	113,134	0.2	47,961,604	77.2	10,833,748	17.4

Sensitivity at State Level

At the state level, the changes in geographic assignation showed greater variation between classification systems than at the beneficiary level. The largest difference was found when comparing the RUCA and FORHP classification systems. The differences ranged from <0.1 % to 12.1%. The largest amount of change in geographic distribution (>6%) occurred for six states: West Virginia, Alaska, Louisiana, Delaware, and Hawaii. Appendix B lists of all states by geography.

Discussion

It is important to understand the changes that occur when using different rural classification systems as these definitions are used to inform policy and provide funding for rural populations. Overall, this analysis demonstrated that differences between definitions occur mainly at the ZIP code level, suggesting that differences were based on the unit of measure, county or ZIP code, and not on the specific classification system

used. This was supported by the almost identical results when comparing CBSA codes to the UIC codes at the national level. There were more variations in results at the beneficiary level and the state level when comparing the RUCA to FORHP, which use ZIP code to identify areas. This suggests that smaller geographic areas, in this case ZIP code was smaller than county, resulted in more differences between definitions. Among all definitions, the FORHP most measured similar to[1] the U.S. Census 2010 rural population of 19.3%.[2] RUCA codes assigned the largest number of beneficiaries as rural dwelling.

At the state level, the largest changes that occurred changed the classification of beneficiaries from rural dwelling to urban dwelling. Thus, when requesting funding, states should consider the definitions used in classifying rurality while understanding which system may be of greater benefit to their rural areas; using the RUCA codes to assign rurality may be most beneficial to states.

The characteristics of rural Medicare beneficiaries aligned with findings from the literature, except for age. Rural Medicare beneficiaries across all classification systems were mostly white, women, age of 18-84, and had a higher proportion of persons with disabled status when compared to urban Medicare beneficiaries. Contrary to prior findings in the literature, within the Medicare population urban areas had higher proportions of the oldest patients (85+) when compared to rural areas. It may be that

[1]Using the FORHP definition, 22.0% of Medicare were considered rural dwelling.

many Medicare beneficiaries 85 and older move to more urban locations for either informal care by family members or formal healthcare services.

Limitations and Future Research

Although this analysis used the complete national file of Medicare beneficiaries for 2018, these results may not be generalizable beyond the Medicare population. Additionally, the RUCA to ZIP code linking file was incomplete; the complete file was not accessible at the time of this analysis. An incomplete linking file was used, resulting in 499,917 beneficiaries missing RUCA codes. This number may seem large, but it is not limiting as more than 60 million observation remained in the analytic file after excluding beneficiaries with missing RUCA codes. This may be a limitation of this study as missingess in ZIP codes may be systematic given that small size leads to variation and ZIP code is correlated with small size.

Another limitation of this study was that out of more than 17 different classification systems of rurality used in federal agencies, this analysis compared only four due to limited availability of geographic variables in the Medicare beneficiary enrollment file. Research could expand on this beneficiary level analysis by using Census tracts (which provide a smaller unit of measure) on Medicare beneficiary data.[50] Future research could also focus on rural hospital payments and the effects of how the definition of rurality on Medicare payments to rural hospitals and other rural providers. Additionally, further research might focus on the healthcare implications to suburban areas after the shift in population from urban areas to suburban areas during the COVID-19 pandemic.[51]

CHAPTER III

PREDISPOSING CHARACTERISTICS OF HIGH EMERGENCY DEPARTMENT USE IN RURAL MEDICARE BENEFICIARIES

Introduction and Background

Frequent emergency department (ED) use is of interest in the research and policy arenas as a small amount of patients incur the highest costs for healthcare systems and taxpayers.[29] On the other hand, ED visits may be what keeps rural hospitals open as they provide revenue from the high cost of these services.[23,52] As the cost of healthcare continues to rise, the need for efficient services, especially for high cost populations, is a main concern for rural hospitals that are struggling to remain financially viable.[53] Federal leadership has shifted focus from eliminating or reducing the use of ED services in rural areas to identifying solutions for healthcare systems transformation.[53-57] This research will inform policy and healthcare systems on the chronic conditions that drive Medicare FFS ED utilization.

Frequent ED Users

Health services research has identified high ED users as patients who frequent the emergency department four or more times per year.[58-59] In both urban and rural areas, high ED utilization is a symptom of a healthcare system's lack of prioritizing preventive and specialized services. Most of the healthcare expenditure in emergency department room visits come from few patients that utilize these services with high frequency, accounting for around 28% of all ED visits.[60-63] Less than a third of ED users returned to the emergency department for two consecutive years, and were more likely to die at the

point of their last emergency department visit when compared to non-frequent ED users.[64] Evidently, frequent ED patients have poor health that usually requires urgent medical attention and subsequent hospitalization, even death.[63,65]

The literature has demonstrated that patients with high use of the ED described the need for utilizing these services as vital.[52] The literature has characterized frequent ED patients as generally insured, white, with a mean age around 40, and generally sicker than non-ED users.[62,64] Most were Medicaid or Medicare enrolled, and were only reusing the emergency department temporarily.[64] The literature on ED utilization has established that among high cost emergency department patients the most common conditions, in descending order, were congestive heart failure, diabetes, lung disease, kidney disease, cancer, ischemic heart disease, stroke, behavioral/mental illness, substance abuse, and liver disease.[66]

Due to the current challenges in healthcare for rural areas, the general findings from prior research on ED utilization may not hold. Findings in the literature specific to rural areas have depicted a rising use in ED services at a greater rate than in urban areas.[52] Outpatient ED rural visits from 2005 through 2016 increased for non-Hispanic white patients, Medicaid beneficiaries, those aged 18 to 64 years, and for the uninsured.[52] Rural ED visit rates increased by more than 50% (36.5 to 64.5 visits per 100 people), far greater than urban ED visit rates (40.2 to 42.8 visits per 100 persons); nearly one-fifth of all ED visits occurred in rural communities.[52] Evidently, rural communities have a substantial need for the emergency department as an increasing source of service to address the health needs of their communities.

Research Questions

1: What are the demographic characteristics of rural Medicare high emergency department utilizers?

2: Why do rural Medicare high ED patients repeatedly use of ED services?

Hypothesis

Demographic characteristics of rural Medicare high ED utilizers will reflect those of rural populations, and frequent ED users will reflect findings from the literature: mostly an older population, female, non-Hispanic white patients who were not dually enrolled. After controlling for demographic characteristics and dual coverage, the top principal conditions associated with high ED utilization will be congestive heart failure, diabetes, lung disease, kidney disease, and cancer.

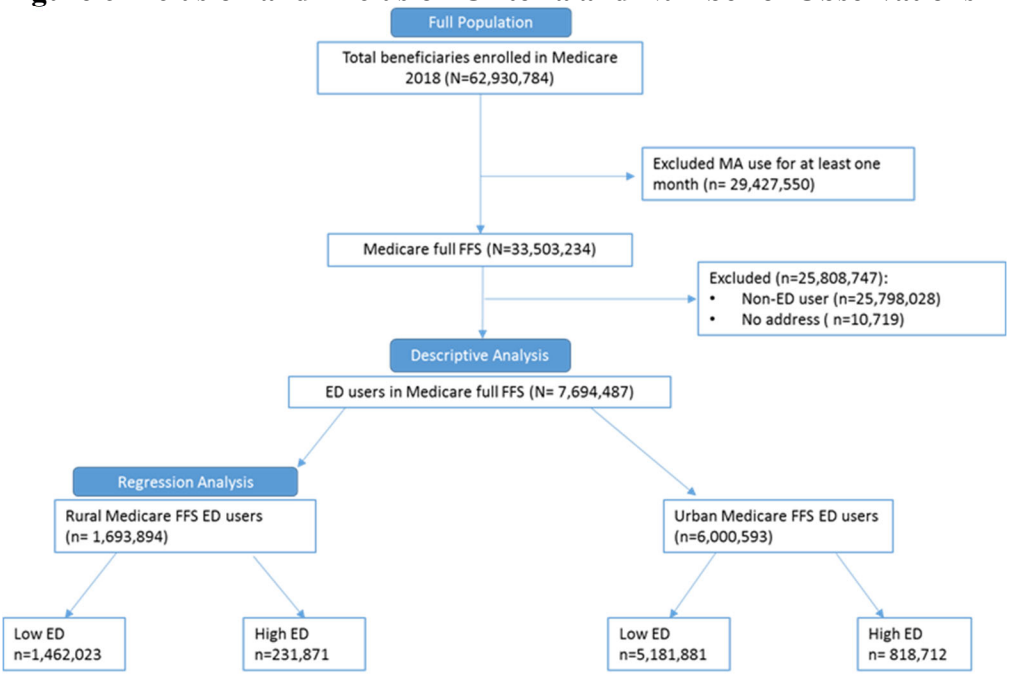
Methodology

Data Source

This analysis was conducted using the Medicare Geographic Variation Database, which includes Medicare enrollment data detailed in Chapters I and II; this was merged with Part A and Part B claims and utilization files. Medicare part A files provided information on inpatient hospital admissions, while part B files provided information on outpatient hospital stays.[3] These files included information on beneficiary enrollment, demographic characteristics, diagnosis related groups (DRG), principal diagnoses, and amount of ED use. Due to the lack of access to full claims data for the MA population, I excluded observations from beneficiaries that were not enrolled in fee-for-service Medicare at any time during 2018 (n=29,427,550). I also excluded observations without

ZIP codes (n=10,719), and beneficiaries that did not visit the ED in 2018 (n=25,798,028). The final analytic dataset contained rural Medicare FFS ED users with 7,694,478 observations. Figure 6 outlines the number of observations included and excluded for this analysis.

Figure 6 Inclusion and Exclusion Criteria and Number of Observations



The data were subset by geography to limit the regression dataset to rural Medicare FFS beneficiaries (n=1,693,891). Following the recommendation of The Centers for Medicare & Medicaid Service (CMS) Office of Minority Health, rurality was defined using the CBSA classification system where rural included micropolitan (population <50,000) and non-CBSA (population<10,000).

Variables

The main variables of interest for this analysis were chronic conditions that could be associated with high ED use. Theoretically, drug use and uncontrolled chronic

conditions could account for high ED utilization.[30,63,67] The chronic conditions included in this analysis were based on prior literature on ED use. They were: congestive heart failure, diabetes, obesity, hypertension, lung disease, kidney disease, cancer, ischemic heart disease, stroke, mental and behavioral illness, conditions related to older adults, such as hip fractures and mobility impairment, and substance abuse disorders. Additionally, I included chronic conditions that were related to the top 20 principal diagnoses and DRGs (identified through ICD-10 codes) informed by the Medicare 2018 claims data. These additional chronic conditions included: anemia, migraines, and brain injury.

ED use was dichotomized into low ED use for beneficiaries that had less than 4 visits a year, and high ED use for beneficiaries that had 4 or more visits per year.[67-71] This dataset included beneficiary characteristics of age, sex, race and ethnicity[2], severity of illness, dual eligibility for Medicare and Medicaid, disability status, death (included in the dataset), household median income, and county of residence. Age, sex, race and ethnicity were included to control for differences in demographic characteristics. Race and ethnicity was derived from the Research Triangle Institute (RTI) imputation, described in more detail in Chapter II.[48] Severity of illness was derived from the hierarchical condition category (HCC) scores which provide a weight per beneficiary based on spending, diagnosis codes, healthcare utilization, and health conditions from the beneficiary's prior year of enrollment.[42] Beneficiaries enrolled in full or partial

[2] The categories for race and ethnicity were: white (non-Hispanic), Black or African-American, Asian or Pacific Islander, Hispanic, and American Indian or Alaska Native.

Medicaid benefits were flagged as dual eligible. The geographic variables included in this dataset were state, county FIPS code, and ZIP code.

Analysis

I conducted a secondary data analysis of Medicare claims and enrollment data for the year 2018 using SAS version 9.4. First, a descriptive analysis of the data was performed at the beneficiary level by geography and stratified by type of ED use (high and low). This was followed by a claims level analysis of ED users and their reasons for their visit using claims and utilization data. I identified claims of FFS beneficiaries who had used the emergency department at least once in 2018 to summarize the top 20 DRGs for ED visits that resulted in inpatient stays, and the top 20 principal diagnoses of outpatient ED use. The results were stratified by 1) those with low ED use (less than four ED visits a year), and 2) those with high ED use (four ED visits or more a year). The top DRGs and principal diagnoses were used to inform the main predictors for the logistic regression analysis.

Regression Analysis

After applying exclusion criteria and formatting variables for the final analytic dataset, I ran univariate analyses followed by pairwise correlations to explore the relationships between the variables in the model. I drew a random sample of 1% from the full population to use as robustness check for the regression analyses.[72] The dependent variable for the logistic regression models was being a high ED user or low ED users (0=low ED utilization, 1=high ED utilization). I tested for magnitude of effects chronic conditions had on frequent emergency department using the odds ratio (OR).

I tested all models using the Hosmer and Lemeshow (H-L) goodness-of-fit test.[73] The H-L did not reject the model using the 1% sample. I further tested this model using the concordance index or "c-statistic" which showed that the partial and full models were a good fit using the 1% sample (c-statistic of 0.76 and 0.77).[74] Therefore, I drew results from the 1% sample regression analysis. I included results of the full population models as they reflected true differences and associations among the variables. I also tested the models by including interaction terms of race and chronic conditions, but eliminated these terms since they did not improve the fit of the model as the Akaike information criterion (AIC) was higher and the c-statistic lower and the results for statistical significance of associations were unchanged.

Results

Of all FFS Medicare enrollees (N=33,503,234), 23% (n=7,694,487) used the emergency department at least once in 2018. Of those who used the ED, most beneficiaries only used the ED once throughout the year (mean=2.1, median=1, and mode=1); the visits ranged from one visit to a maximum of 854 visits. Among beneficiaries who used the ED, 14% (n=1,050,583) returned to the emergency department four or more times a year (frequent ED users).

Descriptive Analysis Results

Among all FFS Medicare ED users, most of the population (70%) was aged 65-84, female (55%), more than 80% were white, and approximately a quarter were considered disabled. When stratifying demographic characteristics by type of ED use (high and low), the results were similar across ED use. Table 9 lists the demographic

characteristics of ED users by frequency of use. When comparing low ED users to high ED users, we only see percentage differences ranging from 0.01% to 2.01%. The largest difference occurred across age categories where high ED users had lower proportions of the population under 75 years and higher proportions of those over 75 years of age. Compared to low ED users, there was a slightly higher proportion (0.8%) of beneficiaries identified as disabled within the population of high ED users.

Table 9 Medicare Emergency Department User Characteristics by type of ED use

Characteristics	All ED users (n=7,694,487)		Low ED users (n=6,643,904)		High ED Users (n=1,050,583)	
Age	N	%	N	%	N	%
0-17	253	<0.01	224	<0.01	29	<0.01
18-64	1,129,206	14.7	975,977	14.7	153,229	14.6
65-74	3,092,092	40.2	2,688,183	40.5	403,909	38.5
75-84	2,354,276	30.6	2,020,081	30.4	334,195	31.8
85+	1,118,660	14.5	959,439	14.4	159,221	15.2
Total	**7,694,487**	**100.0**	**6,643,904**	**100.0**	**1,050,583**	**100.0**
Sex						
Male	3,464,557	45.0	2,992,510	45.0	472,047	44.9
Female	4,229,930	55.0	3,651,394	55.0	578,536	55.1
Race/Ethnicity						
White	6,165,570	80.1	5,321,942	80.1	843,628	80.3
Black	677,149	8.8	584,411	8.8	92,738	8.8
Hispanic	440,288	5.7	380,881	5.7	59,407	5.7
API	199,574	2.6	172,854	2.6	26,720	2.5
AIAN	43,767	0.6	37,867	0.6	5,900	0.6
Unknown	168,139	2.2	145,949	2.2	22,190	2.1
Disabled Status	1,797,165	23.4	1,549,034	23.4	248,131	23.7

ED Users by Geography

Approximately 70% of ED users in both urban and rural areas, were between the ages of 65-84; however most (~40%) were in the younger age range (65-74). Regardless of geography or type of ED use, there were more female than male ED users and more than 77 % of the beneficiaries were white.

Across ED utilization types, rural areas consistently resulted in higher proportions of white beneficiaries (+10%), when compared to urban areas. Regardless of geography, there were slightly higher percentages of disability status for high ED users when compared to low ED users. Table 10 provides a breakdown of beneficiary characteristics of ED users by geography and type of use (low ED versus high ED use).

Table 10 Medicare Emergency Department User Characteristics by Geography and Type of ED use

	Rural ED Users (N=1,693,894)				Urban ED Users (N=6,000,593)			
Characteristics	**Low ED Users (n=1,462,023)**		**High ED Users (n=231,871)**		**Low ED Users (n=5,181,881)**		**High ED Users (n=818,712)**	
Age	N	%	N	%	N	%	N	%
0-17	46	<0.01	2	<0.01	178	<0.01	27	<0.01
18-64	240,603	16.5	38,238	16.5	735,374	14.2	114,991	14.1
65-74	585,775	40.1	88,228	38.1	2,102,408	40.6	315,681	38.6
75-84	440,996	30.2	72,745	31.4	1,579,085	30.5	261,450	31.9
85+	194,603	13.3	32,658	14.1	764,836	14.8	126,563	15.5
Total	1,462,023	100	231,871	100	5,181,881	100	818,712	100
Sex								
Male	677,585	46.4	107,624	46.4	2,314,925	44.7	364,423	44.5
Female	784,438	53.7	124,247	53.6	2,866,956	55.3	454,289	55.5
Race/ethnicity								
White	1,283,205	87.8	203,675	87.8	4,038,737	77.9	639,953	78.2
Black	86,544	5.9	13,881	6.0	497,867	9.6	78,857	9.6
Hispanic	41,333	2.8	6,489	2.8	339,548	6.6	52,918	6.5
API	8,645	0.6	1,398	0.6	164,209	3.2	25,322	3.1
AIAN	20,164	1.4	3,129	1.4	17,703	0.3	2,771	0.3
Unknown	22,132	1.5	3,299	1.4	123,817	2.4	18,891	2.3
Disabled Status	401,455	27.5	64,742	28.0	1,147,579	22.2	183,389	22.5

Top Diagnosis-Related Groups for Inpatient ED use (Medicare Part A)

The top 20 DRGs of Medicare Part A for ED use reflected 40.3% of all hospital admission that began in the ED (inpatient ED visits). Appendix C provides a list of the top 20 DRGs and top 20 principal diagnoses for all Medicare FFS inpatient ED visits. These reflected seven categories: conditions of the heart, kidney failure, respiratory conditions, digestive disorders, stroke, infections, and dehydration. Table 11 lists the top 20 DRGs for inpatient ED use grouped into seven categories.

Table 11 Medicare FFS Part A Reasons for ED use

Reason for ED use	*% of all ED use*
Infections	12.6
Heart conditions	8.2
Respiratory conditions	7.5
Kidney failure	6.0
Digestive disorders	3.5
Stroke	1.3
Dehydration	1.1

When stratifying by geography and type of ED use, the top 20 DRGs for rural and urban populations were very similar. Of all Medicare FFS inpatient ED visits, the top 20 DRGs were similar for both rural and urban patients with high and low ED use (Table 12). A detailed table of the top 20 DRGs by type of ED use and Geography can be found in Appendix D. The results varied mostly for respiratory conditions; rural Medicare beneficiaries had lower proportions (0.6% less) of respiratory conditions, and higher proportions for kidney failure and digestive disorders by 0.1% when compared to rural.

Table 12 Medicare FFS Part A Reasons for ED use by Geography and Type of ED use

	Low ED Users		*High ED Users*	
Reason for ED use	**Rural DRG %**	**Urban DRG %**	**Rural DRG %**	**Urban DRG %**
Infections	12.6	12.6	12.6	12.6
Heart conditions	8.2	8.2	8.2	8.3
Respiratory conditions	7.0	7.6	7.0	7.6
Kidney failure	6.1	6.0	6.1	6.0
Digestive disorders	3.6	3.5	3.6	3.5
Stroke	1.3	1.3	1.3	1.3
Dehydration	1.1	1.1	1.2	1.1

Top Principal Diagnoses for Outpatient ED Use (Medicare Part B)

The top 20 principal diagnoses account for approximately 30% of all ED visits that resulted in an outpatient hospital visit (Medicare Part B). The top 20 principal diagnoses from the ED use claims data showed that chest pain and respiratory conditions reflect more than 10% of all Medicare FFS outpatient ED use. Table 13 lists the top 20 principal diagnoses grouped into ten categories. Appendix C provides a detailed list of the top 20 principal diagnoses for FFS Medicare Part B, outpatient ED visits.

Table 13 Medicare FFS Part B Reasons for ED use

Reasons for ED use	***% of all ED use***
Chest pain	5.6
Respiratory conditions	5.2
Weakness, dizziness, syncope	3.5
Back, head, and abdominal pain	1.8
Urinary tract infection	1.2
Digestive issues	0.8
Hypertension	0.8
Head injury	4.3
Nose bleeds	1.4
Dehydration	2.5

Of all Medicare FFS outpatient ED visits, the top 20 principal diagnoses were similar for both rural and urban patients with high and low ED use. The largest differences occur for respiratory conditions and digestive issues. Among both low ED and high ED users, rural areas had lower proportions of respiratory conditions as the reason for ED use when compared to urban areas (Table 14). A detailed table of the top 20 principal diagnoses by type of ED use and Geography can be found in Appendix E. Among low ED users, rural areas had higher proportions of digestive issues as the reason for ED use when compared to urban areas.

Table 14 Medicare FFS Part B Reasons for ED use

	Low ED Users		***High ED Users***	
Reason for ED use	**Rural DRG %**	**Urban DRG %**	**Rural DRG %**	**Urban DRG %**
Chest pain	5.6	5.6	5.6	5.6
Respiratory conditions	4.1	5.3	4.9	5.4
Weakness, dizziness, syncope	4.3	4.3	4.2	4.3
Back, head, and abdominal pain	3.6	3.5	3.6	3.5
Urinary tract infection	2.5	2.5	2.4	2.5
Digestive issues	2.4	1.8	1.7	1.8
Hypertension	1.4	1.4	1.4	1.4
Head injury	1.2	1.2	1.2	1.2
Nose bleeds	0.8	0.9	0.8	0.8
Dehydration	0.8	0.8	0.7	0.8

Regression Analysis Results

To understand which conditions (informed by the claims data and the literature) were associated with high ED use among FFS Medicare beneficiaries, two sets of regressions were run for this analysis: 1) a partial model with only the chronic conditions as predictors, and 2) a full model which controlled for race and ethnicity, dual eligibility,

demographics (indicators of disability, gender, and age), death, and state of residence. These were run with the full population and the 1% random sample. Median household income and presence of an ED within the beneficiary ZIP code had a high correlation between each other and rurality type, causing multicolinearity. I eliminated the variables of presence of an ED and county median household income as the model that only included rurality type resulted in a better fit with the lowest AIC score and a higher c-statistic. Appendix F and Appendix G provide the detailed information of all regression analyses.

The results from the partial and full regression models showed that brain injury, peripheral vascular disease, PTSD, personality disorder, lung cancer, and colon cancer were not associated with frequent emergency department use. The model controlling for the rich set of predictors was a better fit with a lower AIC, when compared to the partial model. The only difference between the partial and full model was that in the full model, diabetes was not associated with high ED use. The models revealed that people diagnosed with chronic migraines, ADHD, and drug use disorders were approximately twice as likely to be high ED users, when compared to ED users who were not diagnosed with these conditions. Although statistically significant in both the partial and full model, people diagnosed with obesity only had a 17% and 15%, respectively, increased odds of being high ED users when compared to ED users who did were not diagnosed with obesity. Table 15 lists the results from the regression analyses for the 1% sample partial and full models. With the exception of state of residence and severity of illness, the control variables were not statistically significant.

Table 15 Regression Analysis using the 1% Sample

	Partial Model[+]				Full Model[‡]			
	1% of the population (n=16,550)				1% of the population (n=16,550)			
Predictors of High ED Use	Odds Ratio	95% Confidence Interval Upper	Lower	*p*	Odds Ratio	95% Confidence Interval Upper	Lower	*p*
Anemia	1.75	1.58	1.94	***	1.67	1.50	1.86	***
Asthma	1.61	1.39	1.86	***	1.56	1.34	1.82	***
Diabetes	1.11	1.00	1.23	*	1.07	0.96	1.19	
Hypertension	1.21	1.04	1.42	*	1.20	1.02	1.42	*
Migraines	2.04	1.70	2.46	***	2.01	1.66	2.44	***
Obesity	1.17	1.05	1.30	**	1.15	1.03	1.29	*
Brain Injury	1.40	0.96	2.04		1.42	0.97	2.09	
Peripheral vascular disease	1.11	1.00	1.23		1.07	0.95	1.19	
Stroke	1.59	1.38	1.84	***	1.63	1.41	1.90	***
Chronic heart failure	1.53	1.37	1.70	***	1.51	1.34	1.69	***
Acute myocardial infarction	1.55	1.25	1.91	***	1.69	1.35	2.11	***
Ischemic heart disease	1.25	1.12	1.40	***	1.21	1.08	1.36	***
Chronic kidney disease	1.52	1.36	1.70	***	1.50	1.34	1.68	***
Chronic obstructive pulmonary disorder	1.43	1.29	1.59	***	1.41	1.26	1.57	***
Drug use disorder	1.91	1.61	2.25	***	1.83	1.54	2.19	***
Alcohol use disorder	1.46	1.18	1.81	***	1.33	1.06	1.68	*
Anxiety disorder	1.61	1.44	1.79	***	1.57	1.40	1.76	***
Schizophrenia	1.24	1.04	1.49	*	1.25	1.04	1.51	*
Post-traumatic stress disorder	1.17	0.87	1.58		1.28	0.93	1.75	
Personality Disorder	1.24	0.96	1.59		1.23	0.95	1.60	
Bipolar disorder	1.55	1.31	1.85	***	1.57	1.31	1.89	***
Attention deficit hyperactivity disorder	1.91	1.42	2.57	***	2.03	1.49	2.77	***
Major depressive disorder	1.24	1.11	1.39	***	1.24	1.11	1.39	***
Lung cancer	0.98	0.73	1.31		0.95	0.71	1.28	
Colon cancer	1.26	0.96	1.67		1.27	0.95	1.69	
Hip/pelvic fracture	1.48	1.17	1.87	**	1.58	1.24	2.01	***
Mobility impairment	1.34	1.14	1.58	***	1.25	1.05	1.48	*

Note: *p<0.05, **p<0.01, ***p<0.001

[+]The partial model only included the chronic conditions as predictors without controlling for other variables
‡The rich set of predictors controls for race and ethnicity, dual eligibility for Medicare and Medicaid, demographics (indicators of being disabled, gender, and age), death, and state of residence.

Discussion

On August 11th, 2020, CMS had a press release that explained current national priorities in healthcare are focused on innovating how medical services are provided for rural communities.[9] The results from this analysis will inform transformation of EDs in rural communities as it provides an understanding of rural Medicare high cost ED users. These results were useful in informing on characteristics of rural Medicare ED users, why they used the ED, and the chronic conditions associated with high ED use.

The results from the first part of this analysis were consistent with the literature. Rural Medicare ED user characteristics reflected a younger population (within the realm of Medicare beneficiaries), mostly white, female, and not considered disabled.[68,75] Most beneficiaries used the emergency department only once, while only 14% used the ED 4 or more times. Characteristics for high ED users were similar to those of low ED users, where the only differences occurred by geography. That is, low and high ED users look the same demographically, but differ by geography. In line with the literature, when stratifying by geography, rural areas consistently had higher proportions of white beneficiaries and were less ethnically diverse than urban areas.

The second part of this analysis informed on the reasons for ED use through analyzing claims data for the top 20 DRGs and principal diagnoses for Medicare Part A and Part B claims. The top reasons for ED use were chronic conditions related to heart and pulmonary diseases; symptoms of chronic conditions such as infection or inflammation; and issues related to falls such as syncope, collapse, and head injury. The results also include constipation and urinary tract infections, which reflect legitimate

conditions older adults (>65) are often diagnosed with.[76] The literature has demonstrated that diseases of the liver are associated with high cost ED use, but this was not consistent with the results from the top 20 DRGs or principal diagnoses. This may be due to an increase in deaths for people diagnosed with liver disease among 25-34 years old, which means this population would not live to reach the age of Medicare enrollment.[77]

The third part of this research was conducted through a set of regression analyses to inform on chronic conditions that were associated with high ED use. While the first two descriptive analyses of this research reflected the literature on rural areas and ED use, the logistic regression contradicts some of results from prior studies. This may be due to the different populations used in prior research. The results from the regression showed that, contrary to the prior literature, diabetes and cancer were not associated with high ED use in this population. The results from this analysis mirrored that congestive heart failure, lung disease, kidney disease, cancer, ischemic heart disease, stroke, mental illness, and substance abuse were associated with high ED use. Unexpectedly, beneficiaries diagnosed with ADHD had the highest odds of being frequent emergency department users among all behavioral and mental health conditions; they were more than twice as likely to be high ED users when compared to those who were not diagnosed with ADHD. Although the literature does mention behavioral and mental illness is associated with high ED use, it is unclear how ADHD could affect repeat use of ED services.

Of the rich set of predictors used to control for beneficiary characteristics, only severity of illness and state of residence were statistically significant. This may reflect

that this population is very sick and their emergency department use was based on legitimate healthcare needs and not necessarily on available of ED services. Consistent with the literature, these results suggest that ED utilization for this population was necessary for their survival. In line with current research on ED use, the results showed that drug use disorders were among the top three conditions with the highest likelihood of being a frequent ED users.

Results from this analysis may provide rural hospitals with information on conditions that could become a source of financial stability to provide a more efficient use of ED services for targeted conditions. This may also provide opportunities to integrate service in the ED for chronic conditions associated with high ED use.

Limitations and Future Research

Although the full Medicare beneficiary population was employed for this analysis, the results from this study may not be generalizable to the general population of ED users as Medicare beneficiaries reflect a population that is generally 65 or older. This research may only be generalizable to the Medicare FFS populations. This carries implications of selection bias as rural areas tend to have less options for MA enrollment. The differences related to the type of enrollment (MA vs. FFS) reflect the differences between urban and rural areas where FFS has greater proportions of white beneficiaries and a less diverse population. Table 1 in Chapter I details the demographic characteristics by enrollment type. Because we use the entire population of over 7 million ED users, this study was overpowered. For this reason, the regression analysis

was conducted on the 1% samples of the population and the best fit model was used to inform the results from this analysis.

Future research could expand on this beneficiary level analysis to focus on rural hospital inpatient admissions and payments through claims data analysis. This would inform on what conditions are associated with high use of other hospital resources and inform on a population with high medical costs. Future analyses could also look at the location of ED use and that of the beneficiary admission, or subsequent admission within one or two days. This would provide information on rural beneficiaries who go to the local ED but are transferred to other hospitals and availability of local services due to their condition. Future healthcare utilization research could also focus on geographic differences between suburban and rural areas.

CHAPTER IV

EMERGENCY DEPARTMENT UTILIZATION AMONG RURAL MEDICARE BENEFICIARIES BY HOSPITAL REFERRAL REGION

Introduction and Background

Introduction

Building on the analysis from Chapter III, which described frequent emergency department (ED) patients in rural Medicare populations, this analysis examined where ED users sought emergency care and which chronic conditions were associated with leaving their hospital market areas. Rural healthcare services are generally constrained by a shortage of physicians and financially fraught healthcare systems.[4,56] Thus, rural populations rely on hospitals, often their emergency rooms, to provide a range of services including primary care and long-term care services.[4,14]

Frequent ED users (≥4 ED visits per year) and dually eligible beneficiaries (qualifying for both Medicare and Medicaid benefits) are vulnerable populations that manage multiple chronic conditions.[3,78] Healthcare needs are generally greater for dually eligible beneficiaries than for Medicare only beneficiaries.[78] As such, these population require care that may not be available in a rural areas, often facing a choice of using their local hospital market or seeking services outside of their local market.[28-29]

Hospital referral regions (HRR), created by Dartmouth Atlas in 1993, are boundaries that capture healthcare markets to better understand hospital patterns of utilization given the need for specialized care. These boundaries were based on a study of Medicare

hospitalizations in 3,436 geographic service areas.[20,79] These areas were then grouped into 306 HRRs reflecting the local market patterns of resource allocation and hospital utilization.[79-80] Each ZIP code was assigned an HRR that has at least one hospital that offered specialized tertiary care.[79] HHRs have been widely used in health services research to examine healthcare markets over the last 27 years.[81-83] To my knowledge, HRRs have not been used for analyzing patterns of ED use among rural Medicare beneficiaries.

Background

Rural hospitals rely on their EDs as a source of financial solvency as they provide a frequent source of care for rural residents.[52] When a rural patient decides to use their non-local healthcare services, rural hospitals forgo this source of revenue. To potentially retain this source of income, it is important to identify characteristics of those who do seek care outside of their HRRs and to address the needs of rural ED users. Retaining patients within their rural hospital markets promotes financial sustainability of a hospital, and may decrease the risk of patient mortality when patients with acute medical conditions (such as severe sepsis or septic shock) seek care outside of their service region.[84] Through this analysis, I characterized rural Medicare beneficiaries who bypassed their HRR for ED care. To my knowledge, there is no prior published research focused on rural ED bypass behavior.

Hospital Referral Regions

The literature varies in how rural hospital bypass (utilizing services outside the local hospital market) has been measured; it ranges from measuring bypass through

conditional logits to physical distance of the patient's home to their healthcare facility.[85-86] This analysis used HRR to measure utilization patterns as it is the only measure that has been adopted by the Centers for Medicare & Medicaid Services to identify trends in utilization using healthcare markets.[42] I used HRRs for this analysis as this measure was developed using Medicare utilization data, and is thus the most accurate in describing the hospital market areas for the population in this study. [21,79]

Research Questions

1: What are the demographic characteristics of rural Medicare ED users who bypass their hospital referral region?

2: Which chronic conditions make rural Medicare ED users more likely to seek care outside of their HRR?

3: Do rural Medicare beneficiaries identified as high ED users (>4 ED visits per year) have higher odds than low ED users (<4 ED visits per year) of using emergency services outside of their HRR?

Hypothesis

Demographics and dual-coverage of the rural population that used ED services outside of their HRR will reflect those of the general rural Medicare population; older, non-Hispanic, white, females not identified as dually eligible. Noting that the healthcare needs are greater for dual eligible beneficiaries than for Medicare only beneficiaries, and the limitations that rural areas have in access to healthcare, dual beneficiaries will be more likely to use services outside of their hospital referral region. Frequent ED users,

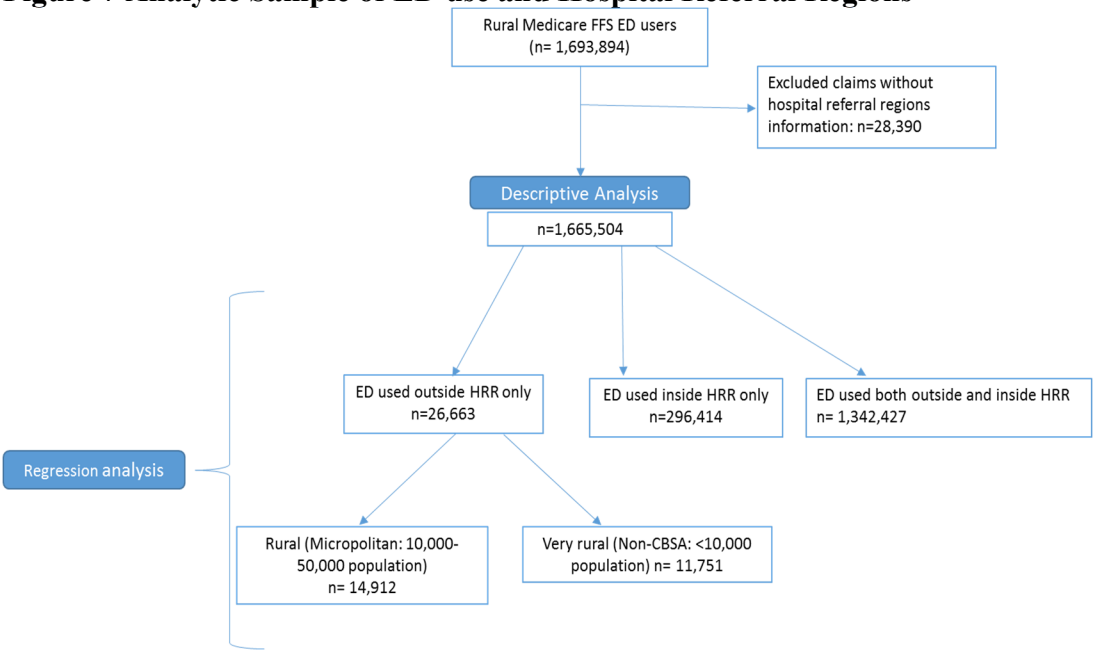
when compared to low ED users, will be more likely go outside their HRR for ED services.

Methodology

Data Source

This retrospective study was conducted using Medicare beneficiary enrollment and utilization data for the year 2018. This analysis focused on FFS rural Medicare ED users living in the 50 states and Washington D.C. (N= 1,693,894). The larger dataset from which this analytic sample was derived, has been detailed in Chapter III. This analysis was restricted to the FFS population and beneficiaries who had information on their assigned HRR as well as their provider's HRR (excluded n=28,390).[45] Figure 7 details the dataset used for these analyses.

Figure 7 Analytic Sample of ED use and Hospital Referral Regions



Variables

This analysis focused on characteristics that may affect use of ED services outside of the beneficiary's hospital market. The main variable of interest for the descriptive analysis was where ED services were rendered: 1) within the beneficiary's hospital market (inside their HRR), 2) outside the patient's hospital market (outside their HRR), 3) both inside and outside the beneficiary's hospital market (both HRRs). The claims data included the beneficiary's assigned HRR and the HRR for provider of service.

When there were discordant pairs of assigned HRRs (between the beneficiary and the provider of service), this flagged that the beneficiary used services outside of their HRR. For the regression analysis, this variable was dichotomized to better understand the population that used services exclusively outside of their HRRs (1= used services only outside their HRR; 0= used services inside their HRR or used services both inside and outside of their HRR).

The main predictors used for the regression analysis included level of rurality, chronic conditions associated with high ED use, and the beneficiary's use of the ED in the year 2018. Rurality was defined through the core-based statistical area (CBSA) classification system where rural included both micropolitan and non-CBSA populations. For this analysis, which only includes the rural population, rurality was defined in two levels: 1) micropolitan, with a population between 10,000 and 50,000; and 2) non-CBSA, with a population less than 10,000. The chronic conditions included in this analysis were informed by prior literature and 2018 Medicare claims data detailed

in Chapter III: congestive heart failure, diabetes, obesity, hypertension, lung disease, kidney disease, cancer, ischemic heart disease, stroke, mental and behavioral illness, conditions related to older adults, such as hip fractures and mobility impairment, substance abuse disorders, anemia, migraines, and brain injury. In line with the literature on frequent ED use, high ED users were identified as having ≥4 ED visits per year and low ED users as <4 ED visits per year.[28-29,68]

Control variables included in this analysis were demographic characteristics of age, sex, race and ethnicity, dual enrollment, disability status, severity of illness, and death. Age was transformed into 5 categories of ages 1) 0-17, 2) 18-64, 3)65-74, 4) 75-84, and 5) 85 and older. Sex was a dichotomous variable with categories of male and female. Race and ethnicity was included in the beneficiary enrollment data through an algorithm developed by the Research Triangle Institute (RTI) to reduce the number of beneficiaries with missing data.[48] The RTI imputation method produced categories[3] consistent with current government-wide standards set by the Office of Management and Budget.[48]

Beneficiaries enrolled in Medicare and full or partial Medicaid benefits were considered dually eligible.[87] To control for severity of illness, I included the annual hierarchical condition category (HCC) which accounts for each beneficiary's prior year of healthcare services and expenditures. The date of death was included in the Medicare data set if the patient died during the year 2018. Using this information, I created a

[3] The categories for race and ethnicity were: white (non-Hispanic), Black or African-American, Asian or Pacific Islander, Hispanic, and American Indian or Alaska Native.

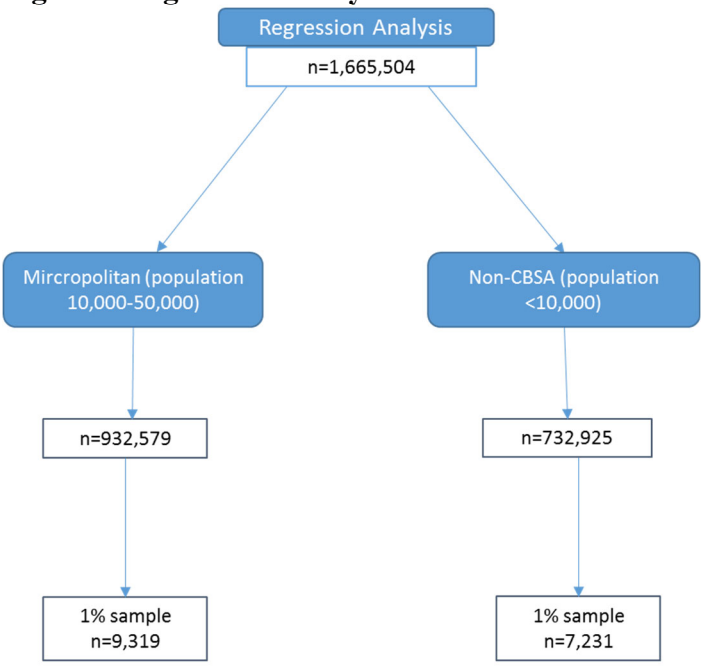
dummy variable that flagged those who died to include this as a control in the regression analysis.

Analysis

This research employed a retrospective descriptive analysis and logistic regression using SAS version 9.4. After applying exclusion criteria and formatting variables for the final analytic dataset, I summarized the variables of interest through univariate analyses noting frequency and percentages. The descriptive portion of this analysis employed simple frequencies and proportions. I tested for associations between variables and eliminated beneficiary state of residence since it was highly correlated with level of rurality and created multicolinearity in the models.

I ran logistic regressions with two sets of models for 1) rural areas with a population of 10,000 to 50,000 (micropolitan), and 2) rural areas with less than 10,000 (non-CBSA) with a population to analyze differences between the two levels of rurality. The dependent variable was the beneficiary's use of ED services outside of their HRR. Both models were run for each population size using 2 different analytic datasets: 1) the full population of ED users (n=1,665,504), and 2) a 1% random sample of ED users (n=16,550). The first set of models included beneficiaries residing in micropolitan areas and run using the full population and the 1% random sample of Medicare FFS ED users. The second set of regressions was limited to beneficiaries residing in non-CBSA areas using the full population and the 1% random sample of Medicare FFS ED users. Figure 8 depicts the analytic datasets used for each regression model.

Figure 8 Regression Analytic Datasets



Given the number of observations for the rural population was larger than 1 million and could have been overpowered, the two sets of regressions were run using a 1% random sample. The regression models included the main predictors of high ED use, chronic conditions related to congestive heart failure, diabetes, obesity, hypertension, lung disease, kidney disease, cancer, ischemic heart disease, stroke, mental and behavioral illness, conditions related to older adults, such as hip fractures and mobility impairment, substance abuse disorders, anemia, migraines, and brain injury. The regression models controlled for race and ethnicity, dual eligibility, demographics (indicators of disability, gender, and age), death, and severity of illness.

After running all models, I reviewed Akaike Information Criterion (AIC) scores and tested for model fit using the Hosmer and Lemmeshow (H-L) goodness-of-fit test.[76] I further tested the model using the concordance index or "c-statistic" which showed that

the 1% random was a good fit (c-statistic of 0.73).[77] The model that used the 1% sample was also a good fit using the H-L test. I drew results from the 1% sample regressions and the full population; the results from the full population models reflected all Medicare beneficiaries for which confidence intervals and levels of significance may not be relevant.

Results

Descriptive Analysis

Within rural areas (for both levels of rurality), the majority of beneficiaries who used the ED (>80%) used these services both inside and outside of their HRR. Only 1.6% used ED services exclusively outside of their HRR, and 17.8% used services exclusively inside of their hospital referral region. These proportions remained consistent within both levels of rurality. Medicare beneficiary characteristics were also similar across both levels of rurality, as seen in Table 16. For both types of rural categories, regardless of where beneficiaries chose to receive ED services, approximately 90% of ED users were white. The most rural areas (non-CBSA) had higher proportions of black beneficiaries when compared to micropolitan areas, whereas micropolitan areas had higher proportions of Hispanic beneficiaries when compared to non-CBSAs.

Table 16 Demographics of ED Medicare beneficiaries by use of Hospital Referral Region and Level of Rurality

Characteristics	Micropolitan (N=932,579)			Non-CBSA (N=739,925)		
	Inside only (n=165,786)	Outside only (n=14,912)	Both (n=751,881)	Inside only (n=130,625)	Outside only (n=11,751)	Both (n=590,546)
Age	%	%	%	%	%	%
0-17	<0.01	-	<0.01	<0.01	<0.01	<0.01
18-64	16.4	16.5	16.8	15.9	15.6	16.2
65-74	36.2	33.9	40.7	36.1	34.3	40.6
75-84	32.7	33.1	29.4	33.4	33.8	30.1
85+	14.7	16.6	13.2	14.6	16.3	13.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Sex						
Male	45.8	46.1	46.0	46.8	46.7	46.9
Female	54.2	53.9	54.0	53.2	53.3	53.2
Race/ethnicity						
White	87.6	88.2	87.4	88.4	88.9	88.2
Black	5.8	5.2	5.8	6.2	6.2	6.2
Hispanic	3.2	3.2	3.3	2.2	1.9	2.2
API	0.7	0.8	0.7	0.5	0.4	0.5
AIAN	1.2	1.2	1.2	1.6	1.4	1.6
Unknown	1.5	1.3	1.7	1.2	1.3	1.4
Disabled Status	27.9	28.0	27.4	28.1	27.7	27.6

Regression Analysis

The results from the regression analyses were not consistent between the full population regressions and the 1% sample regressions. The results from the 1% sample regressions showed that in micropolitan areas beneficiaries that identified as high ED users were almost 3 times more likely to use an ED outside of the beneficiary's HRR than those who were not high ED users, while in non-CBSAs being a high ED user was

not associated with using ED services outside of the beneficiary's HRR. In micropolitan areas, the chronic conditions associated with ED use outside of the beneficiary's HRR were brain injury, chronic heart failure, schizophrenia, lung cancer, hip/pelvic fracture, and mobility impairment. Of the control variables, only being female and dually eligible were associated with using services outside of a patient's HRR in micropolitan areas. In the most rural areas (non-CBSA), only anemia and those with CKD were associated with using ED services outside of the beneficiary's HRR. None of the control variables in the 1% non-CBSA model were statistically significant for associations with ED use outside of the beneficiary's HRR. Table 17 lists the results of the regression analyses for the predictors of interest.

Table 17 Regression Analyses Using 1% Sample

N=1,665,504	**Micropolitan (population 10,000-50,000)**				**Non-CBSA (population <10,000)**			
	1% of the rural population (n=9,319)				1% of the most rural population (n=7,231)			
Predictors of Using ED outside of HRR	Odds Ratio	95% Confidence Interval Upper	Lower	*p*	Odds Ratio	95% Confidence Interval Upper	Lower	*p*
High ED use	**2.72**	**1.82**	**4.07**	***	1.51	0.96	2.39	
Anemia	1.33	0.89	1.98		**1.68**	**1.10**	**2.56**	*
Asthma	0.71	0.36	1.41		1.33	0.74	2.36	
Diabetes	0.68	0.45	1.01		0.79	0.52	1.21	
Hypertension	1.32	0.70	2.48		1.11	0.60	2.05	
Migraines	1.03	0.46	2.30		0.78	0.30	1.99	
Obesity	0.99	0.65	1.50		1.29	0.85	1.97	
Brain Injury	**2.90**	**1.15**	**7.33**	*	1.03	0.24	4.44	
Peripheral vascular disease	1.24	0.84	1.84		0.71	0.45	1.12	
Stroke	1.18	0.70	1.99		1.27	0.72	2.24	
Chronic heart failure	**2.00**	**1.30**	**3.06**	**	1.02	0.65	1.60	
Acute myocardial infarction	1.75	0.89	3.44		1.17	0.46	2.99	
Ischemic heart disease	0.82	0.54	1.25		1.03	0.67	1.57	

Chronic kidney disease	1.37	0.90	2.08		**1.63**	**1.04**	**2.56**	*
Chronic obstructive pulmonary disorder	1.05	0.70	1.58		1.21	0.79	1.86	
Drug use disorder	1.14	0.57	2.26		0.95	0.43	2.08	
Alcohol use disorder	1.62	0.76	3.44		1.00	0.39	2.57	
Anxiety disorder	0.78	0.50	1.20		1.25	0.80	1.94	
Schizophrenia	**1.93**	**1.05**	**3.54**	*	1.68	0.84	3.36	
Post-traumatic stress disorder	2.01	0.65	6.21		1.25	0.36	4.44	
Personality Disorder	0.38	0.09	1.65		1.33	0.50	3.55	
Bipolar disorder	0.80	0.38	1.70		0.68	0.29	1.55	
Attention deficit hyperactivity disorder	1.76	0.66	4.69		0.81	0.18	3.65	
Major depressive disorder	1.11	0.73	1.68		1.14	0.73	1.78	
Lung cancer	**2.80**	**1.23**	**6.36**	*	0.82	0.25	2.67	
Colon cancer	1.00	0.36	2.79		1.97	0.78	5.02	
Hip/pelvic fracture	**2.87**	**1.53**	**5.39**	**	1.82	0.85	3.88	
Mobility impairment	**1.76**	**1.03**	**2.99**	*	1.34	0.70	2.56	
Control Variables								
Disabled Status	1.17	0.66	2.08		0.85	0.46	1.59	
American Indian/Alaska Native	<0.001	<0.001	>999.999		0.57	0.08	4.17	
Hispanic	0.91	0.28	2.93		0.77	0.19	3.20	
Black	1.75	0.89	3.47		1.30	0.64	2.65	
Asian/Pacific Islander	<0.001	<0.001	>999.999		1.98	0.25	15.48	
Other	1.58	0.47	5.28		0.56	0.08	4.14	
Female	0.68	0.47	0.97	*	0.85	0.59	1.25	
Severity of illness	0.97	0.86	1.08		0.98	0.86	1.10	
Death	1.15	0.51	2.55		1.43	0.67	3.06	
Age	0.82	0.34	1.93		1.27	0.53	3.04	
Dually eligible	0.42	0.23	0.77	**	0.89	0.53	1.48	

Note a: *p<0.05, **p<0.01, ***p<0.001

The results from the regressions that used the full population of rural FFS Medicare beneficiaries showed that micropolitan and non-CBSA areas had similar

results for chronic conditions associated with ED use outside of the beneficiary's HRR. The largest difference between the two levels of rurality occurred for beneficiaries with diagnosed pelvic or hip fracture with an OR difference of only 0.12 points, where the OR was 1.55 for micropolitan areas versus an OR of 1.67 for non-CBSA areas. In both micropolitan and non-CBSAs, beneficiaries with high ED use were almost 2.5 times more likely than low ED users to use ED services outside of the beneficiary's HRR. The control variables for the full population of micropolitan beneficiaries that were statistically significant were: having a disability, being of black race, and age. The control variables for the full population of non-CBSA dwelling beneficiaries that were statistically significant were: being Hispanic and age. Table 18 lists the predictors of using ED outside of the beneficiary's HRR for micropolitan and non-CBSA regressions.

Table 18 Regression Analyses with Full Population

	Micropolitan				**Non-CBSA**			
Predictors of Using ED outside of HRR	100% of the rural population (n=932,579)				100% of most rural the population (n=732,925)			
	Odds Ratio	95% Confidence Interval		*p*	Odds Ratio	95% Confidence Interval		*p*
		Upper	Lower			Upper	Lower	
High ED use	2.46	2.36	2.55	***	2.49	2.38	2.60	***
Anemia	1.46	1.40	1.52	***	1.51	1.45	1.58	***
Asthma	0.97	0.91	1.02		1.00	0.93	1.06	
Diabetes	0.87	0.84	0.90	***	0.85	0.81	0.88	***
Hypertension	1.41	1.33	1.50	***	1.35	1.26	1.44	***
Migraines	0.94	0.87	1.01		0.90	0.82	0.98	*
Obesity	0.91	0.88	0.95	***	1.00	0.96	1.05	
Brain Injury	1.39	1.23	1.58	***	1.47	1.28	1.68	***
Peripheral vascular disease	1.18	1.13	1.22	***	1.15	1.10	1.20	***
Stroke	1.28	1.22	1.35	***	1.27	1.20	1.34	***
Chronic heart failure	1.23	1.18	1.28	***	1.20	1.15	1.25	***
Acute myocardial infarction	1.26	1.17	1.36	***	1.27	1.17	1.38	***
Ischemic heart disease	1.05	1.01	1.09	*	1.05	1.01	1.10	*
Chronic kidney disease	1.32	1.27	1.38	***	1.29	1.23	1.35	***

Chronic obstructive pulmonary disorder	1.09	1.05	1.14	***	1.09	1.04	1.13	***
Drug use disorder	0.97	0.90	1.03		0.88	0.81	0.95	***
Alcohol use disorder	1.17	1.08	1.27	***	1.21	1.11	1.33	***
Anxiety disorder	1.10	1.06	1.14	***	1.03	0.99	1.08	
Schizophrenia	1.50	1.42	1.59	***	1.46	1.36	1.56	***
Post-traumatic stress disorder	0.86	0.76	0.97	*	0.85	0.74	0.97	*
Personality Disorder	1.06	0.96	1.16		1.07	0.96	1.18	
Bipolar disorder	1.10	1.04	1.18	**	1.13	1.05	1.21	**
Attention deficit hyperactivity disorder	1.60	1.46	1.77	***	1.61	1.44	1.80	***
Major depressive disorder	1.14	1.09	1.18	***	1.17	1.12	1.22	***
Lung cancer	1.22	1.11	1.34	***	1.12	1.01	1.25	*
Colon cancer	1.18	1.08	1.30	***	1.24	1.12	1.37	***
Hip/pelvic fracture	1.55	1.45	1.67	***	1.67	1.54	1.80	***
Mobility impairment	1.23	1.16	1.30	***	1.14	1.06	1.21	***
Control Variables								
Disabled Status	1.09	1.03	1.15	**	1.05	1.54	1.803	
American Indian/Alaska Native	0.88	0.75	1.04		0.88	0.75	1.04	
Hispanic	0.87	0.76	1.00		0.87	0.76	1.00	*
Black	1.02	0.94	1.10	**	1.02	0.94	1.10	
Asian/Pacific Islander	0.91	0.68	1.22		0.91	0.68	1.22	
Other	1.08	0.92	1.28		1.08	0.92	1.28	
Female	0.99	0.96	1.03		0.99	0.96	1.03	
Severity of illness	0.99	0.98	1.00		0.99	0.98	1.00	
Death	0.96	0.88	1.05		0.96	0.88	1.05	
Age	0.91	0.86	0.96		0.84	0.77	0.92	
Dually Eligible	0.96	0.91	1.01		0.96	0.91	1.01	
Note a: *p<0.05, **p<0.01, ***p<0.001								

Discussion

One could conclude that because very rural (non-CBSA) areas may have more limited access to healthcare services, beneficiaries residing there would be more likely to use ED services outside of their HRR.[4,23,28] However, descriptive results from this analysis showed that patterns of ED service utilization did not vary by geography. That

is, the level of rurality did not affect a beneficiary's use of ED services outside of their HRR. This may be reflective of the type of services ED users are seeking, which include urgent and lifesaving care and thus likely seek these services within their market area.[28,65,68] The literature has established that the dually eligible population has greater healthcare needs and require higher levels of specialized care than non-dually eligible beneficiaries, suggesting that being dually eligible may affect where a beneficiary seeks care.[28,49,88] However, the results from this analysis showed that for the population of FFS Medicare ED users, dually eligibles were not more likely to seek ED services outside of their HRR. The characteristics of ED users were similar when stratified by HRR. There were minor differences in ORs when looking at characteristics of patients who used ED services within the beneficiary's HRR, outside of their HRR, and those who used both. This suggests that the beneficiary demographic characteristics themselves do not affect choice of ED services.

A diagnosis of traumatic brain injury, lung cancer, or hip/pelvic fracture were associated with the highest likelihood, almost 3 times more likely than those without these conditions, to use emergency services outside of the beneficiary's HRR. This suggests that those who use ED services had a legitimate need to seek care outside of their HRR as they may require a higher level of specialty care. The results from the regression analyses confirm that geography does not make a large difference in beneficiary choice of ED hospital market, but being a high user ED does. That is, those who seek ED services often are more likely to use ED services away from their local hospital market.

Limitations and Future Research

One limitation of this study was that the results from this analysis may not be generalizable to beneficiaries covered by managed care as FFS and MA plans do not share the same mix of services or type of beneficiary. FFS covers an older population and more vulnerable population which tends to utilize more healthcare services.[92] Differences between MA and FFS for descriptive characteristics of beneficiaries mostly reflected geography. A strength of this analysis is that it used the full population of FFS Medicare beneficiaries enrolled in the year 2018.

The socioeconomic status and access to transportation of beneficiaries likely affect utilization patterns of ED services, impacting the choice of which hospital to use (within their HRR versus outside of their HRR).[4,14] This analysis did not include income level or access to transportation for beneficiaries, but did include dual eligibility which may act as a proxy for low income.[78] HRRs used in this analysis may not reflect the most recent data on Medicare utilization, as the HRRs were created more than 20 years ago. However, the results from this analysis demonstrate that HRRs correctly capture about 80% of the utilization of Medicare beneficiaries' ED markets. This is reflective of prior literature that found that Medicare enrolled beneficiaries had lower rates than those with private insurance of bypassing services in their local health markets.[24]

Future research could use hospital service areas (HSA) to understand a more local hospital market as they are based on smaller regions that HRRs, therefore, HSAs could provide more detailed information on trends of ED use within rural areas.[45,81] An extension to this research could include analyzing the data of the 1.6% of ED users who

chose to use hospital services outside their HRR to identify where the beneficiaries go when they don't use their local hospital market. Analyzing claims level data could inform on the financial impact the 1.6% of rural ED users who bypass their local markets have on rural hospitals and the healthcare gaps within rural areas. Future work may also look at the extent of travel within non-urban areas stratified by micropolitan and rural geography. This could inform on whether beneficiaries seek care at tertiary facilities within major metropolitan areas or bypass their rural facility to seek care in micropolitan areas.

CHAPTER V

CONCLUSION AND DISCUSSION

Rural healthcare systems experience challenges of access to care for patients, financial sustainability for hospitals, and often face a shortage of healthcare providers.[4,90] Rural communities rely on local hospitals as a safety net of access to care of "last resort" for vulnerable populations; these services are often provided through the emergency department.[90-92] Yet, many rural hospitals currently operate on thin financial margins; over 126 rural hospitals have closed since 2010.[24,90] Although, much research has examined health disparities of rural populations in relation to urban areas, fewer studies have focused on understanding the needs of rural populations to address their healthcare utilization.[36] Using Medicare enrollment and claims data, this study described the characteristics of rural Medicare beneficiaries, identified the reasons for emergency department (ED) utilization, and the patterns of rural inpatient and outpatient emergency department use.

How federal policy defines "rurality" will continue to affect funding for grants and healthcare for rural areas through adjusted payments. The most current push for rural healthcare reform through funding comes from the Centers for Medicare & Medicaid Services' (CMS), guided by the Presidential executive order on Improving Rural Health and Telehealth, implementation of the Community Health Access and Rural Transformation (CHART) Model on August 11th, 2020.[9] This initiative aims to test rural health care systems innovation by providing new funding opportunities that will increase access and improve quality of care for rural residents, and build a

sustainable system of care for hospitals.[9] The Office of Management and Budget (OMB) states that rurality may be defined as non-metropolitan areas without specifying which classification system of geography to use.[12] This gives flexibility to CMS, along with other agencies, to provide guidance on the classification system used for defining rurality.

To inform on the classification systems of rurality used in policy, Chapter II (paper 1) measured the differences that occurred across four classification systems of rurality using Medicare enrollment data. This comparative analysis used 4 systems: The US Census Bureau developed Core Based Statistical Area (CBSA) codes; The United States Department of Agriculture's (USDA) Urban Influence Codes (UIC) and Rural-Urban Commuting Area (RUCA) codes; and The Federal Office of Rural Health Policy's (FORHP) rural eligible ZIP codes. The RUCA codes accounted for the largest percentage and count of rural Medicare beneficiaries. Rural proportions of Medicare beneficiaries ranged from 17.8% for UIC and CBSA to 23.5% for RUCA, overall in line with the literature on rurality using these definitions.[35,44]

The demographic characteristics of Medicare beneficiaries were similar across classification systems, where the largest differences were found between rural and urban areas. Overall, this analysis demonstrated that differences between definitions occur mainly at the ZIP code level, suggesting that differences were based on the unit of measure and not on the specific classification system used. It may be beneficial for states seeking funding to use the RUCA classification system as it provided an overall higher count of rural dwelling beneficiaries.

Aligned with prior findings in the literature, rural Medicare beneficiaries across all classification systems were mostly white, women, age of 18-84, and had a higher proportion of persons with disabled status when compared to urban Medicare beneficiaries. Contrary to prior findings from the literature, within the Medicare population, urban areas had higher proportions of the oldest patients (>84) when compared to rural areas. This may suggest that as Medicare beneficiaries grow older they may move to more urban locations for either informal care by family members or formal healthcare services.

To address how the reform of health services delivery could be addressed, Chapter III (paper 2) explored the chronic conditions that brought rural Medicare beneficiaries to the ED. Most Medicare beneficiaries who used the ED in 2018 only used emergency services once throughout the year and only 14% of those who used the ED returned 4 or more times a year (frequent ED users). The top 20 DRGs for inpatient ED use covered 40.3% of all hospital admissions that began in the ED. The top 20 DRGs from inpatient ED visits reflected these seven categories of conditions: conditions of the heart, kidney failure, respiratory conditions, digestive disorders, stroke, infections, and dehydration. The top principal diagnoses for outpatient ED visits were: chest pain, respiratory conditions, weakness, dizziness, syncope, back pain, headache, abdominal pain, urinary tract infection, digestive issues, hypertension, head injury, nose bleeds, and dehydration; these accounted for approximately 30% all outpatient ED services, where chest pain and respiratory conditions accounted for more than 10% of those.

Rural hospitals stand to increase efficiencies and lower costs in delivery of care for rural EDs by developing targeted interventions among populations with chronic conditions related to high ED use. In line with previous research, the results from the regression analysis showed that beneficiaries with drug use disorder were almost twice as likely to be frequent ED users. This may be related to the surge of drug overdose and alcoholism in the US.[93] However, cancer and diabetes, which the literature has shown to be associated high ED use, were not associated with high ED use for rural Medicare beneficiaries in this dataset.

To understand the needs of those seeking care outside of their local hospital markets and potentially retain financial outflow, Chapter IV (paper 3) focused on ED use of Medicare beneficiaries who utilized services outside of their local hospital markets. Approximately 2% of those who used the emergency department used ED services exclusively outside of the beneficiary's hospital market or hospital referral region (HRR). In micropolitan areas (population 10,000-50,000), the chronic conditions associated with ED use outside of the beneficiary's HRR were brain injury, chronic heart failure, schizophrenia, lung cancer, hip/pelvic, and mobility impairment. This is consistent with the general needs of older populations.[76] Although lung cancer was not associated with high ED use, it was associated with leaving the beneficiary's HRR for ED use. However, results were different for beneficiaries residing in the most rural areas (non-CBSA, population <10,000), only anemia and those with chronic kidney disease (CKD) were associated with using ED services outside of the beneficiary's HRR.

The chronic conditions associated with leaving the beneficiary's HRR suggest a need for specialty care that is not readily available in rural EDs, specifically limited access to dialysis facilities in rural areas that address the needs of patients with CKD.[94] Augmenting the capacity for telehealth services in rural EDs to retain Medicare beneficiaries in their own markets may alleviate the beneficiary's higher risk of mortality when traveling outside of their HRR.

Limitations and Future Research

There were several limitations to this study. This study was limited to the Medicare population and may not be generalizable to patients with private insurance as private insurers and Medicare do not share the same mix of services. Medicare covers an older population, which tends to utilize more healthcare services.[95] Due to lack of access to claims data for the Medicare Advantage (MA) population, Chapters III and IV only included the full fee-for-service (FFS) beneficiaries. Thus, the results from these analyses may not be generalizable to the MA population. This carries implications of selection bias as rural areas tend to have less options for MA enrollment. However, analysis of the FFS compared to the MA population showed that the differences in FFS and MA may reflect the geographic difference between rural and urban areas. However, using the FFS population is also a strength of this study as prior research has found that FFS populations generally provide more uniform care for low income and vulnerable populations.[89] Future research could focus on studies that mirror these analyses for the MA population.

A key strength of his analytic dataset was utilizing information on full populations of rural Medicare and FFS beneficiaries. The results derived from these datasets allowed for a comprehensive representation of the characteristics of rural Medicare beneficiaries, reasons for ED utilization, and seeking ED services outside of the beneficiary's hospital referral regions.

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APPENDIX A

MEDICARE BENEFICIARY CHARACTERISTICS BY GEOGRAPHY AND CLASSIFICATION SYSTEM WITH COUNTS

	CBSA				UIC				RUCA				FORHP			
Characteristic	**Rural**		**Urban**		**Rural**		**Urban**		**Rural**		**Urban**		**Rural**		**Urban**	
Age	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
0-17	301	<0.01	1,507	<0.01	302	<0.01	1,504	<0.01	377	<0.01	1,409	<0.01	360	<0.01	1,448	<0.01
18-64	1,847,376	16.9	7,093,409	14.0	1,851,743	16.9	7,088,621	14.0	2,374,966	16.6	6,509,852	13.9	2,243,441	16.6	6,697,547	13.9
65-74	5,207,517	47.6	25,034,218	49.4	5,221,585	47.6	25,018,998	49.4	6,849,891	47.8	23,116,610	49.4	6,484,143	47.9	23,755,687	49.4
75-84	2,762,976	25.2	12,815,228	25.3	2,771,249	25.2	12,806,533	25.3	3,634,252	25.3	11,814,682	25.3	3,423,982	25.3	12,152,058	25.3
85+	1,129,717	10.3	5,743,614	11.3	1,133,246	10.3	5,739,966	11.3	1,483,379	10.3	5,344,657	11.4	1,394,298	10.3	5,477,028	11.4
Total	10,947,887	100.0	50,687,976	100.0	10,978,125	100.0	50,655,622	100.0	14,342,865	100.0	46,787,210	100.0	13,546,224	100.0	48,083,768	100.0
Sex																
Male	5,183,988	47.4	23,009,487	45.4	5,197,979	47.4	22,994,494	45.4	6,772,397	47.2	21,183,660	45.3	6,413,269	47.3	21,777,746	45.3
Female	5,763,897	52.7	27,678,482	54.6	5,780,144	52.7	27,661,121	54.6	7,570,466	52.8	25,603,543	54.7	7,132,952	52.7	26,306,016	54.7
Race/ethnicity																
White	9,497,292	86.8	36,627,172	72.3	9,526,569	86.8	36,597,776	72.3	12,346,491	86.1	33,381,205	71.4	11,717,755	86.5	34,402,923	71.6
Black	734,790	6.7	5,836,594	11.5	735,165	6.7	5,836,214	11.5	968,859	6.8	5,575,891	11.9	874,620	6.5	5,696,792	11.9
Hispanic	328,533	3.0	4,688,497	9.3	330,077	3.0	4,686,911	9.3	516,158	3.6	4,454,353	9.5	465,294	3.4	4,548,686	9.5
API	60,590	0.6	2,004,747	4.0	60,731	0.6	2,004,529	4.0	96,549	0.7	1,950,431	4.2	80,856	0.6	1,985,421	4.1
AIAN	135,480	1.2	146,648	0.3	134,015	1.2	146,335	0.3	159,503	1.1	119,441	0.3	165,993	1.2	116,105	0.2
Unknown	191,202	1.8	1,384,318	2.7	191,568	1.7	1,383,857	2.7	255,305	1.8	1,305,889	2.8	241,706	1.8	1,333,841	2.8
Disabled Status	2,990,074	27.4	11,046,449	21.8	2,996,958	27.4	11,038,991	21.8	3,842,384	26.9	10,104,127	21.6	3,629,068	26.9	10,406,849	21.7

APPENDIX B

MEDICARE BENEFICIARY ENROLLMENT BY STATE AND GEOGRAPHY

	# of	CBSA		UIC		RUCA		FORHP	
State/District	Beneficiaries	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Alabama	1,076,807	26.7	73.3	26.7	73.3	35.5	64.5	32.6	67.4
Alaska	101,522	35.5	64.5	35.1	64.9	43.4	56.6	52.3	47.7
Arizona	1,331,193	5.8	94.2	5.8	94.2	19.5	80.5	15.0	85.0
Arkansas	657,570	44.0	56.0	44.0	56.0	49.6	50.4	47.8	52.2
California	6,427,832	3.4	96.6	3.4	96.6	8.5	91.5	7.9	92.1
Colorado	925,055	15.9	84.1	15.9	84.1	17.1	82.9	17.9	82.1
Connecticut	700,278	6.2	93.8	6.2	93.8	6.1	93.9	7.3	92.7
Delaware	210,638	0.0	100.0	0.0	100.0	33.5	66.5	27.0	73.0
Florida	4,618,227	3.5	96.5	3.5	96.5	8.0	92.0	4.5	95.5
Georgia	1,760,493	22.3	77.7	22.3	77.7	28.3	71.7	24.6	75.4
Hawaii	279,936	21.7	78.3	21.7	78.3	33.3	66.7	27.1	72.9
Idaho	335,429	29.1	70.9	35.1	64.9	38.7	61.3	38.1	61.9
Illinois	2,302,536	15.2	84.8	15.2	84.8	18.5	81.5	17.4	82.6
Indiana	1,296,347	25.2	74.8	25.2	74.8	30.0	70.0	30.5	69.5
Iowa	643,217	47.4	52.6	47.4	52.6	53.0	47.0	51.4	48.6
Kansas	549,969	36.5	63.5	36.5	63.5	45.0	55.0	42.5	57.5
Kentucky	956,972	47.6	52.4	47.6	52.4	54.9	45.1	53.8	46.2
Louisiana	893,423	18.0	82.0	18.0	82.0	30.5	69.5	22.8	77.2
Maine	346,556	45.0	55.0	45.0	55.0	56.0	44.0	57.7	42.3
Maryland	1,063,063	3.8	96.2	3.8	96.2	9.4	90.6	5.6	94.4
Massachusetts	1,367,231	1.9	98.1	1.9	98.1	4.0	96.0	3.5	96.5
Michigan	2,123,498	22.1	77.9	22.1	77.9	23.8	76.2	25.0	75.0
Minnesota	1,044,920	29.0	71.0	29.0	71.0	36.6	63.4	35.2	64.8
Mississippi	620,010	57.9	42.1	57.9	42.1	62.1	37.9	60.0	40.0
Missouri	1,264,205	29.7	70.3	29.7	70.3	36.1	63.9	33.9	66.1
Montana	233,999	67.5	32.5	67.5	32.5	67.7	32.3	70.4	29.6
Nebraska	355,226	42.3	57.7	42.3	57.7	48.9	51.1	45.6	54.4
Nevada	537,167	12.8	87.2	12.8	87.2	13.3	86.7	16.3	83.7
New Hampshire	304,278	43.0	57.0	43.0	57.0	43.7	56.3	45.5	54.5
New Jersey	1,662,940	0.0	100.0	0.0	100.0	1.2	98.8	1.2	98.8
New Mexico	429,395	33.9	66.1	33.9	66.1	35.8	64.2	38.2	61.8
New York	3,732,870	8.8	91.2	8.8	91.2	12.7	87.3	12.5	87.5

North Carolina	2,023,622	26.5	73.5	26.5	73.5	36.8	63.2	33.4	66.6
North Dakota	134,286	55.1	44.9	55.1	44.9	56.9	43.1	58.3	41.7
Ohio	2,411,051	22.2	77.8	22.2	77.8	24.1	75.9	26.3	73.7
Oklahoma	760,010	37.1	62.9	38.8	61.2	45.9	54.1	46.6	53.4
Oregon	876,874	21.3	78.7	21.3	78.7	35.3	64.7	30.9	69.1
Pennsylvania	2,815,125	13.3	86.7	13.3	86.7	20.3	79.7	17.3	82.7
Rhode Island	226,660	0.0	100.0	0.0	100.0	2.7	97.3	0.2	99.8
South Carolina	1,089,349	17.5	82.5	17.5	82.5	30.8	69.2	24.9	75.1
South Dakota	179,447	52.6	47.4	52.2	47.8	58.8	41.2	62.0	38.0
Tennessee	1,390,657	28.0	72.0	28.0	72.0	37.1	62.9	34.1	65.9
Texas	4,229,831	15.8	84.2	15.8	84.2	20.7	79.3	20.2	79.8
Utah	405,774	13.4	86.6	13.4	86.6	19.3	80.7	18.4	81.6
Vermont	150,401	71.7	28.3	71.7	28.3	78.4	21.6	77.7	22.3
Virginia	1,541,930	19.0	81.0	19.0	81.0	24.5	75.5	21.5	78.5
Washington	1,385,185	14.2	85.8	14.2	85.8	18.1	81.9	18.4	81.6
Washington, D.C.	97,241	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
West Virginia	454,794	41.4	58.6	41.4	58.6	55.4	44.6	43.3	56.7
Wisconsin	1,198,869	31.4	68.6	31.4	68.6	36.9	63.1	37.2	62.8
Wyoming	111,808	69.5	30.5	69.5	30.5	69.5	30.5	70.6	29.4

APPENDIX C

TOP 20 DIAGNOSIS-RELATED GROUPS AND PRINCIPAL DIAGNOSES FOR ALL ED USE

	All ED Use			
	Top 20 DRG's	**%**	**Top 20 Principal Diagnoses**	**%**
1	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours with major complication or comorbidity	8.1	Other chest pain	2.8
2	Heart failure and shock with major complication or comorbidity	4.9	Chest pain, unspecified	2.8
3	Simple pneumonia & pleurisy with major complication or comorbidity	2.1	Urinary tract infection, site not specified	2.5
4	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours without major complication or comorbidity	2.1	Syncope and collapse	1.7
5	Pulmonary edema and respiratory failure	1.9	Dizziness and giddiness	1.5
6	Esophagitis, gastroenteritis, and miscellaneous digestive disorders without major complication or comorbidity	1.9	Chronic obstructive pulmonary disease with (acute) exacerbation	1.5
7	Chronic obstructive pulmonary disease with major complication or comorbidity	1.8	Essential (primary) hypertension	1.4
8	Kidney and urinary tract infections without major complication or comorbidity	1.8	Low back pain	1.2
9	Renal failure with complication or comorbidity	1.7	Unspecified injury of head, initial encounter	1.2
10	Gastrointestinal hemorrhage with comorbidity or complication	1.7	Headache	1.2
11	Simple pneumonia & pleurisy with complication or comorbidity	1.6	Unspecified abdominal pain	1.2
12	Renal failure with major complication or comorbidity	1.4	Weakness	1.1
13	Intracranial hemorrhage or cerebral infarction with complication or comorbidity or tissue plasminogen activator in 24 hours	1.3	Pneumonia, unspecified organism	1.0
14	Cellulitis without major complication or comorbidity	1.3	Acute bronchitis, unspecified	1.0

15	Heart failure and shock with complication or comorbidity	1.2	Acute upper respiratory infection, unspecified	1.0
16	Kidney and urinary tract infections without major complication or comorbidity	1.1	Constipation, unspecified	0.9
17	Miscellaneous disorders of nutrition, metabolism, fluids/electrolytes without major comorbidity or complication (dehydration)	1.1	Nausea with vomiting, unspecified	0.9
18	Infectious and parasitic disease with procedure with major complication or comorbidity	1.1	Epistaxis	0.8
19	Acute myocardial infarction, discharged alive with major complication or comorbidity	1.1	Dehydration	0.8
20	Cardiac arrhythmia and conduction disorders with comorbidity or complication	1.1	Bronchitis, not specified as acute or chronic	0.7

APPENDIX D

TOP 20 DIAGNOSIS-RELATED GROUPS BY TYPE OF ED USE AND GEOGRAPHY

	Low ED Users				High ED Users			
	Rural DRGs	**%**	**Urban DRGs**	**%**	**Rural DRGs**	**%**	**Urban DRGs**	**%**
1	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours with major complication or comorbidity	8.0	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours with major complication or comorbidity	8.1	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours with major complication or comorbidity	8.0	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours with major complication or comorbidity	8.1
2	Heart failure and shock with major complication or comorbidity	4.9	Heart failure and shock with major complication or comorbidity	5.0	Heart failure and shock with major complication or comorbidity	4.9	Heart failure and shock with major complication or comorbidity	5.0
3	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours without major complication or comorbidity	2.2	Simple pneumonia & pleurisy with major complication or comorbidity	2.2	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours without major complication or comorbidity	2.2	Simple pneumonia & pleurisy with major complication or comorbidity	2.2
4	Simple pneumonia & pleurisy with major complication or comorbidity	2.0	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours without major complication or comorbidity	2.1	Simple pneumonia & pleurisy with major complication or comorbidity	2.0	Septicemia or severe sepsis without mechanical ventilation for more than 96 hours without major complication or comorbidity	2.1
5	Esophagitis, gastroenteritis, & miscellaneous digestive disorders without major complication or comorbidity	1.9	Pulmonary edema and respiratory failure	1.9	Esophagitis, gastroenteritis, and miscellaneous digestive disorders without major complication or comorbidity	1.9	Pulmonary edema and respiratory failure	1.9
6	Pulmonary edema & respiratory failure	1.9	Esophagitis, gastroenteritis, and miscellaneous digestive disorders without major complication or comorbidity	1.9	Pulmonary edema and respiratory failure	1.9	Esophagitis, gastroenteritis, and miscellaneous digestive disorders without major complication or comorbidity	1.9
7	Kidney and urinary tract infections without major complication or comorbidity	1.8	Chronic obstructive pulmonary disease with major complication or comorbidity	1.8	Kidney and urinary tract infections without major complication or comorbidity	1.8	Chronic obstructive pulmonary disease with major complication or comorbidity	1.8

8	Renal failure with complication or comorbidity	1.8	Kidney and urinary tract infections without major complication or comorbidity	1.8	Chronic obstructive pulmonary disease with major complication or comorbidity	1.7	Kidney and urinary tract infections without major complication or comorbidity	1.7
9	Chronic obstructive pulmonary disease with major complication or comorbidity	1.7	Renal failure with complication or comorbidity	1.7	Gastrointestinal hemorrhage with comorbidity or complication	1.7	Renal failure with complication or comorbidity	1.7
10	Gastrointestinal hemorrhage with complication or comorbidity	1.7	Gastrointestinal hemorrhage with comorbidity or complication	1.7	Renal failure with complication or comorbidity	1.7	Gastrointestinal hemorrhage with comorbidity or complication	1.7
11	Simple pneumonia & pleurisy with major complication or comorbidity	1.5	Simple pneumonia & pleurisy with complication or comorbidity	1.6	Simple pneumonia & pleurisy with complication or comorbidity	1.5	Simple pneumonia & pleurisy with complication or comorbidity	1.6
12	Renal failure with major complication or comorbidity	1.4	Renal failure with major complication or comorbidity	1.4	Renal failure with major complication or comorbidity	1.4	Renal failure with major complication or comorbidity	1.4
13	Intracranial hemorrhage or cerebral infarction with complication or comorbidity or tissue plasminogen activator in 24 hours	1.3	Intracranial hemorrhage or cerebral infarction with complication or comorbidity or tissue plasminogen activator in 24 hours	1.3	Cellulitis without major complication or comorbidity	1.3	Intracranial hemorrhage or cerebral infarction with complication or comorbidity or tissue plasminogen activator in 24 hours	1.3
14	bacterial skin infection without major complication or comorbidity	1.3	Cellulitis without major complication or comorbidity	1.3	Intracranial hemorrhage or cerebral infarction with complication or comorbidity or tissue plasminogen activator in 24 hours	1.3	Cellulitis without major complication or comorbidity	1.3
15	Heart failure and shock with major complication or comorbidity	1.1	Heart failure and shock with complication or comorbidity	1.2	Miscellaneous disorders of nutrition, metabolism, fluids/electrolytes without major comorbidity or complication (dehydration)	1.2	Kidney and urinary tract infections without major complication or comorbidity	1.2
16	Miscellaneous disorders of nutrition, metabolism, fluids/electrolytes without major comorbidity or complication (dehydration)	1.1	Kidney and urinary tract infections without major complication or comorbidity	1.1	Heart failure and shock with complication or comorbidity	1.2	Heart failure and shock with complication or comorbidity	1.2
17	Kidney and urinary tract infections with major complication or comorbidity	1.1	Miscellaneous disorders of nutrition, metabolism, fluids/electrolytes without major comorbidity or	1.1	Kidney and urinary tract infections without major complication or comorbidity	1.1	Miscellaneous disorders of nutrition, metabolism, fluids/electrolytes without major comorbidity or	1.1

			complication (dehydration)				complication (dehydration)	
18	Infectious and parasitic disease with OR procedure with major complication or comorbidity	1.1	Infectious and parasitic disease with OR procedure with major complication or comorbidity	1.1	Infectious and parasitic disease with OR procedure with major complication or comorbidity	1.1	Infectious and parasitic disease with OR procedure with major complication or comorbidity	1.1
19	Acute myocardial infarction, discharged alive with major complication or comorbidity	1.1	Acute myocardial infarction, discharged alive with major complication or comorbidity	1.1	Cardiac arrhythmia and conduction disorders with comorbidity or complication	1.1	Acute myocardial infarction, discharged alive with major complication or comorbidity	1.1
20	Cardiac arrhythmia and conduction disorders with comorbidity or complication	1.1	Cardiac arrhythmia and conduction disorders with comorbidity or complication	1.1	Acute myocardial infarction, discharged alive with major complication or comorbidity	1.0	Cardiac arrhythmia and conduction disorders with comorbidity or complication	1.1

APPENDIX E

TOP 20 PRINCIPAL DIAGNOSES BY TYPE OF ED USE AND GEOGRAPHY

	Low ED Users				High ED Users			
	Rural DRGs	**%**	**Urban DRGs**	**%**	**Rural DRGs**	**%**	**Urban DRGs**	**%**
1	Other chest pain	2.8	Other chest pain	2.8	Chest pain, unspecified	2.9	Chest pain, unspecified	2.8
2	Chest pain, unspecified	2.8	Chest pain, unspecified	2.8	Other chest pain	2.78	Other chest pain	2.8
3	Urinary tract infection, site not specified	2.5	Urinary tract infection, site not specified	2.5	Urinary tract infection, site not specified	2.44	Urinary tract infection, site not specified	2.5
4	Syncope and collapse	1.7	Syncope and collapse	1.7	Syncope and collapse	1.7	Syncope and collapse	1.7
5	Dizziness and giddiness	1.5	Chronic obstructive pulmonary disease with (acute) exacerbation	1.5	Dizziness and giddiness	1.55	Chronic obstructive pulmonary disease with (acute) exacerbation	1.5
6	Chronic obstructive pulmonary disease with (acute) exacerbation	1.4	Dizziness and giddiness	1.5	Chronic obstructive pulmonary disease with (acute) exacerbation	1.42	Dizziness and giddiness	1.5
7	Essential (primary) hypertension	1.4	Essential (primary) hypertension	1.4	Essential (primary) hypertension	1.37	Essential (primary) hypertension	1.4
8	Low back pain	1.2	Low back pain	1.2	Headache	1.21	Low back pain	1.2
9	Unspecified abdominal pain	1.2	Unspecified injury of head, initial encounter	1.2	Low back pain	1.18	Unspecified injury of head, initial encounter	1.2
10	Unspecified injury of head, initial encounter	1.2	Headache	1.2	Unspecified abdominal pain	1.18	Unspecified abdominal pain	1.1
11	Headache	1.2	Unspecified abdominal pain	1.1	Unspecified injury of head, initial encounter	1.16	Headache	1.1
12	Weakness	1.1	Weakness	1.1	Weakness	1.02	Weakness	1.1
13	Pneumonia, unspecified organism	0.9	Pneumonia, unspecified organism	1.1	Acute bronchitis, unspecified	0.95	Pneumonia, unspecified organism	1.1
14	Acute bronchitis, unspecified	0.9	Acute bronchitis, unspecified	1.0	Pneumonia, unspecified organism	0.93	Acute bronchitis, unspecified	1.1
15	Constipation, unspecified	0.87	Acute upper respiratory infection, unspecified	1.03	Constipation, unspecified	0.89	Acute upper respiratory infection, unspecified	1.1
16	Nausea with vomiting, unspecified	0.86	Constipation, unspecified	0.88	Acute upper respiratory infection, unspecified	0.88	Constipation, unspecified	0.9

17	Acute upper respiratory infection, unspecified	0.83	Nausea with vomiting, unspecified	0.88	Nausea with vomiting, unspecified	0.85	Nausea with vomiting, unspecified	0.9
18	Epistaxis	0.81	Epistaxis	0.85	Epistaxis	0.84	Epistaxis	0.8
19	Dehydration	0.75	Dehydration	0.75	Dehydration	0.71	Dehydration	0.8
20	Noninfective gastroenteritis and colitis, unspecified	0.67	Bronchitis, not specified as acute or chronic	0.71	Shortness of breath	0.7	Bronchitis, not specified as acute or chronic	0.7

APPENDIX F

REGRESSION ANALYSIS: PARTIAL MODEL

Predictors of High ED Use	Full population (n=1,665,504)				1% of the population (n=16,550)			
	Odds Ratio	95% Confidence Interval		*p*	Odds Ratio	95% Confidence Interval		*p*
		Upper	Lower			Upper	Lower	
Anemia	1.74	1.72	1.76	***	1.75	1.58	1.94	***
Asthma	1.56	1.54	1.59	***	1.61	1.39	1.86	***
Diabetes	1.04	1.03	1.05	***	1.11	1.00	1.23	*
Hypertension	1.22	1.20	1.24	***	1.21	1.04	1.42	*
Migraines	1.82	1.79	1.86	***	2.04	1.70	2.46	***
Obesity	1.16	1.15	1.17	***	1.17	1.05	1.30	**
Brain Injury	1.41	1.35	1.46	***	1.40	0.96	2.04	
Peripheral vascular disease	1.14	1.13	1.15	***	1.11	1.00	1.23	
Stroke	1.49	1.47	1.52	***	1.59	1.38	1.84	***
Chronic heart failure	1.47	1.46	1.49	***	1.53	1.37	1.70	***
Acute myocardial infarction	1.58	1.55	1.62	***	1.55	1.25	1.91	***
Ischemic heart disease	1.22	1.21	1.24	***	1.25	1.12	1.40	***
Chronic kidney disease	1.44	1.43	1.46	***	1.52	1.36	1.70	***
Chronic obstructive pulmonary disorder	1.47	1.45	1.48	***	1.43	1.29	1.59	***
Drug use disorder	1.99	1.96	2.03	***	1.91	1.61	2.25	***
Alcohol use disorder	1.55	1.52	1.58	***	1.46	1.18	1.81	***
Anxiety disorder	1.60	1.58	1.62	***	1.61	1.44	1.79	***
Schizophrenia	1.47	1.45	1.50	***	1.24	1.04	1.49	*
Post-traumatic stress disorder	1.25	1.22	1.29	***	1.17	0.87	1.58	
Personality Disorder	1.18	1.15	1.21	***	1.24	0.96	1.59	
Bipolar disorder	1.42	1.40	1.45	***	1.55	1.31	1.85	***
Attention deficit hyperactivity disorder	1.84	1.78	1.89	***	1.91	1.42	2.57	***
Major depressive disorder	1.26	1.25	1.27	***	1.24	1.11	1.39	***
Lung cancer	1.19	1.16	1.23	***	0.98	0.73	1.31	
Colon cancer	1.34	1.30	1.38	***	1.26	0.96	1.67	
Hip/pelvic fracture	1.39	1.35	1.42	***	1.48	1.17	1.87	**
Mobility impairment	1.32	1.30	1.34	***	1.34	1.14	1.58	***

APPENDIX G

REGRESSION ANALYSIS: FULL MODEL

Predictors of High ED Use	Full population (n=1,505,002)				1% of the population (n=16,550)			
	Odds Ratio	95% Confidence Interval		*p*	Odds Ratio	95% Confidence Interval		*p*
		Upper	Lower			Upper	Lower	
Anemia	1.65	1.63	1.67	***	1.67	1.50	1.86	***
Asthma	1.55	1.53	1.57	***	1.56	1.34	1.82	***
Diabetes	1.00	0.99	1.01		1.07	0.96	1.19	
Hypertension	1.22	1.20	1.24	***	1.20	1.02	1.42	*
Migraines	1.80	1.76	1.83	***	2.01	1.66	2.44	***
Obesity	1.14	1.12	1.15	***	1.15	1.03	1.29	*
Brain Injury	1.39	1.33	1.45	***	1.42	0.97	2.09	
Peripheral vascular disease	1.08	1.07	1.10	***	1.07	0.95	1.19	
Stroke	1.53	1.50	1.55	***	1.63	1.41	1.90	***
Chronic heart failure	1.39	1.37	1.40	***	1.51	1.34	1.69	***
Acute myocardial infarction	1.65	1.62	1.69	***	1.69	1.35	2.11	***
Ischemic heart disease	1.19	1.18	1.21	***	1.21	1.08	1.36	***
Chronic kidney disease	1.38	1.36	1.39	***	1.50	1.34	1.68	***
Chronic obstructive pulmonary disorder	1.43	1.42	1.45	***	1.41	1.26	1.57	***
Drug use disorder	1.93	1.90	1.96	***	1.83	1.54	2.19	***
Alcohol use disorder	1.54	1.51	1.57	***	1.33	1.06	1.68	*
Anxiety disorder	1.58	1.56	1.60	***	1.57	1.40	1.76	***
Schizophrenia	1.47	1.44	1.50	***	1.25	1.04	1.51	*
Post-traumatic stress disorder	1.27	1.24	1.31	***	1.28	0.93	1.75	
Personality Disorder	1.17	1.14	1.20	***	1.23	0.95	1.60	
Bipolar disorder	1.41	1.39	1.44	***	1.57	1.31	1.89	***
Attention deficit hyperactivity disorder	1.83	1.77	1.89	***	2.03	1.49	2.77	***
Major depressive disorder	1.23	1.22	1.25	***	1.24	1.11	1.39	***
Lung cancer	1.14	1.11	1.17	***	0.95	0.71	1.28	

Colon cancer	1.32	1.28	1.35	***	1.27	0.95	1.69	
Hip/pelvic fracture	1.43	1.39	1.46	***	1.58	1.24	2.01	***
Mobility impairment	1.25	1.23	1.27	***	1.25	1.05	1.48	*
Metropolitan	1.00	0.99	1.01		1.04	0.94	1.15	
Disabled Status	1.02	1.00	1.03	*	1.00	0.85	1.17	
American Indian/Alaska Native	0.97	0.93	1.02		0.94	0.60	1.48	
Hispanic	1.00	0.97	1.03		1.06	0.77	1.45	
Black	1.00	0.98	1.03		0.84	0.66	1.07	
Asian/Pacific Islander	1.05	0.98	1.12		1.47	0.76	2.85	
Other	0.96	0.93	1.01		0.95	0.64	1.43	
Female	0.99	0.98	1.00		0.92	0.83	1.01	
Severity of illness	1.10	1.09	1.10	*	1.08	1.05	1.11	***
Death	0.99	0.97	1.02		0.98	0.78	1.24	
Age	0.37	0.09	1.59	*	1.13	0.89	1.43	
Dually Eligible	1.01	1.00	1.02		0.94	0.82	1.07	
State	-	-	-	*	-	-	-	
Note a: *p<0.05, **p<0.01, ***p<0.001								
Note: The states that were statistically significant in the Full population model were: Illinois (**), Kentucky (*), Maine (*), and Michigan (*).								
[+]The partial model only included the chronic conditions as predictors without controlling for other variables								
‡The rich set of predictors adds to the sparse set of predictors: imperfect administrative race-and-ethnicity, Medicare coverage (dually eligible for Medicare and Medicaid, being in a dual or chronic condition Special Needs Plan), demographics								