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The Impact of Patient By-pass Behavior on Rural Hospital Financial Health

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THE IMPACT OF PATIENT BY-PASS BEHAVIOR ON RURAL HOSPITAL FINANCIAL HEALTH

BY

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ABSTRACT

Abstract of Dissertation Presented to the faculty of the Medical University of South Carolina Doctor of Philosophy Program in Health and Rehabilitation Science
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The Impact of Patient Bypass Behavior on Rural Hospital Financial Health

By

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The phenomenon of patients choosing distant, hospitals in lieu of local hospitals is known as bypass behavior. High rates of patient bypass of local hospitals mean a potential loss of revenue which could affect a hospitals financial health. My dissertation addresses the question of how patient bypass behavior impacts rural hospital financial health in three aims, using archival billing data.

My dissertation expands on the existing literature in two ways 1) by evaluating the current measurement of bypass rate and 2) by evaluating the impact of bypass behavior on hospital financial indicators. The results for the patient-level and hospital-level determinates are consistent with the established literature. The exploratory analysis of the association between bypass behavior and hospital financial indicators is promising. Understanding rural patient bypass behavior and its effect on financial indicators is paramount if rural hospitals are to develop alternative responses to help them survive in the ever-evolving healthcare landscape.

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1. INTRODUCTION

1.1 Study Overview

The phenomenon of patients choosing to bypass their local hospital and seek care further from home is known as patient bypass behavior [1]. High rates of patient bypass of local hospitals mean a potential loss of revenue which could affect a hospitals financial health. As such, bypass behavior may be of special concern in thinly-populated rural areas. Rural hospitals have service areas that include almost 20% of all Americans [2], have a significant impact on local economies [3], and are most damaged by patient bypass behavior [4]. Rural Americans are a vulnerable and underserved population with higher mortality rates and greater prevalence of chronic health conditions [5].

Known determinates of bypass behavior include both hospital and patient level characteristics. Previous studies have identified hospital size, ownership, distance and availability of services as the most significant hospital determinates of patient bypass [6-12]. Studies have also found age, sex, insurance status and severity of illness are well-documented patient characteristic that are influential to understanding patient bypass behavior [6, 10].

One in three rural hospitals are at risk of closure due to increasing financial pressures and the inability to attract patients [13]. More than half of all U.S. rural hospital closures since 2010 were in the South [14]. The financial stability of a hospital is dependent upon its ability to attract a critical mass of patients to its facility[14]. The healthcare landscape is drastically changing with policy changes, declining reimbursement rates [14], increased demand for expensive advanced technology [15], and dissatisfied customers

[16]. It is paramount that we understand and measure the effects of patient bypass behavior on hospital financial health if rural hospitals are to weather the storm.

The concept of patient bypass behavior is not new; however, there have been no studies on this phenomenon that seek to explain the relationship between patient bypass behavior and hospital financial health. Previous research has examined the determinates of bypass behavior in various populations and identified the major hospital and patient level characteristics of bypass behavior. The goal of this study is to build on the existing literature and examine the relationship between patient bypass behavior and rural hospital financial health in one state (Florida) for the years 2016 and 2017 using archival data.

1.2 Specific Aims and Hypotheses

This study will examine rural hospital patient bypass behavior and its effect on hospital financial health in the State of Florida for the years 2016 and 2017. The following specific aims and hypotheses were examined using data from the American Association Annual Survey (hospital characteristics), Healthcare Cost and Utilization Project (HCUP) (patient characteristics and financial data), and Medicare Provider Cost Report data from the Healthcare Cost Report Information System (HCRIS) (Table 1).

Specific Aim 1: Describe patient bypass behavior for rural hospital in the State of Florida.

Hypothesis 1: Patient bypass behavior is described by patient characteristics and patients that are male, younger, with lower severity of illness and private insurance are more likely to bypass a local hospital.

Rationale: Age, sex, insurance and severity of illness are well-documented patient characteristic that are influential to understanding which patients are most likely to contribute to bypass behavior [6, 10, 11, 17-20].

Specific Aim 2: Determine which types of rural hospitals in the State of Florida may be most prone to patient bypass behavior.

Hypothesis 2: Rural hospital bypass is impacted by hospital characteristics and hospitals that are publicly owned/ non-profits, with smaller bed counts, lower technical and telehealth capabilities will experience higher rates of bypass.

Rationale: Hospital characteristics (ownership, number of beds, service offerings, technology and location), hospital quality indicators and patient satisfaction are the dimensions of patients' hospital choice found to be most influential to patient bypass behavior and are critical factors in determining where patients seek care [9, 21-23].

Specific Aim 3: Examine the association between rural hospital financial indicators and hospital-level bypass behavior in the State of Florida.

Hypothesis 3: Rural hospital financial health is impacted by patient bypass behavior and hospitals with high rates of patient bypass experience poorer financial performance.

Rationale: Hospitals use financial indicators to measure an institutions health and its responses to environmental changes/opportunities. Lack of understanding the financial impact of patient bypass behavior may place rural hospital at-risk of closure [9, 21-23].

1.3 Significance

The impact of patient bypass behavior on rural hospital financial health is yet to be determined. One in three rural hospitals are at risk of closure due to increasing financial pressures and the inability to attract patients [13]. Rural Americans are a medically vulnerable and underserved population that is high risk of becoming medical underserved by local hospital closure.

Based on the 2010 Census thirty of Florida's sixty-seven counties are rural and outside of a metropolitan area [24]. Forty-four Florida counties are classified as medically underserved [25]. Due to financial pressures, many of the rural hospitals that provide care to these medically underserved counties are at significant risk of closure [14].

Understanding rural patient bypass behavior and its effects on financial health is paramount if rural hospitals are to develop appropriate responses to help them survive in the ever-evolving health care landscape.

Table 1: Study Aims, Research Questions, Hypothesis and Rationale

Specific Aim 1: Describe patient bypass behavior for rural hospitals in the State of Florida.		
Research Question	Hypothesis	Rationale
Which characteristics are most associated with patients bypassing their local hospital?	Patient bypass behavior is described by patient characteristics and patients that are male, younger, with lower severity of illness and private insurance are more likely to bypass a local hospital.	Age, sex, insurance and severity of illness are well-documented patient characteristic that are influential to understanding which patients are most likely to contribute to bypass behavior.
Specific Aim 2: Determine which types of rural hospitals in the State of Florida may be most prone to patient bypass behavior.		
Research Question	Hypothesis	Rationale
Which hospitals characteristics are associated with higher rates of patient bypass?	Rural hospital bypass is impacted by hospital characteristics and hospitals that are publicly owned/ non-profits, with smaller bed counts, lower technical and telehealth capabilities will experience higher rates of bypass.	Hospital characteristics (ownership, number of beds, service offerings, technology and location), hospital quality indicators and patient satisfaction are the dimensions of patients' hospital choice found to be most influential to patient bypass behavior and are critical factors in determining where patients seek care.
Specific Aim 3: Examine the association between rural hospital financial indicators and hospital-level bypass behavior in the State of Florida.		
Research Question	Hypothesis	Rationale
Is rural hospital financial performance affected by patient bypass behavior?	Rural hospital financial health is impacted by patient bypass behavior and hospitals with higher rates of patient bypass experience poorer financial performance.	Hospitals use financial indicators to measure an institutions health and its responses to environmental changes/opportunities. Lack of understanding the financial impact of patient bypass behavior may place rural hospital at-risk of closure.

2. LITERATURE REVIEW

2.1. Background

One in three rural hospitals are at risk of closure due to increasing financial pressures and the inability to attract patients [13]. Patient bypass behavior poses a threat to the overall financial health of rural hospital and the ability of patients that live in rural communities to have timely access to vital health care services locally [26, 27].

60 million Americans live in a rural community and 97% of the United States land is rural [28]. Rural hospitals have primary service areas (PSA) which cover almost 20% of all Americans living in rural communities [2]. A rural hospital is defined as having a service area fewer than 50,000 residents [29]. More than half (53.5%) of all rural hospitals are deemed Critical Access Hospitals (CAHs) by the Centers for Medicare and Medicaid Services (CMS) [30]. CAHs have 25 or fewer beds, are located more than 35 miles from another hospital and provide 24 hour emergency care [29]. In addition to providing access to vital emergent medical services, primary care and preventative services to their communities, rural hospitals have a major impact on the local economy and often serve as a major employer and pillar of the community [31].

2.2. Types of Patient Bypass Behavior

There a two types of patient bypass 1) justifiable and 2) avoidable. Justifiable bypass occurs when the required services or technologies are not offered locally therefore it is justifiable for a patient to receive care outside of the community [16]. Avoidable patient bypass occurs when the desired or needed services are available locally however patients choose to travel outside of the community.

2.3. Defining Patient Bypass

The existing literature has varied in its definition and measurement of bypass. It is often measured in units of time (minutes), distance (miles) or as a rate (percentage). Essentially, to define bypass is to define a hospital's geographic market area and is the first step in measurement.

Adams et al. (1991) defined market area using observed patient choices (hospital discharges) and operationalized it using zip codes [6]. They defined a hospital's market area by the zip codes its patients originate from, controlling for long travel times. There are limitations to using zip codes as they change overtime and are not always consistent with community barriers (geographic areas, disparities, etc.) [4].

In contrast to Adams et al., Buzcko et al. (1992) defined market area using metropolitan statistical areas (MSAs) [32]. A MSA is a core area containing a population nucleus and each MSA must have at least one urbanized areas of 50,000 or more residents. Other studies have used primary care service areas (PCSA) [4] and rural - urban commuting areas codes (RUCA), based on zip codes, to define market area [33, 34]. PCSAs are self-sufficient geographic markets of primary care [35].

2.4. Description of Determinates of Patient Bypass Behavior

The literature examining the phenomenon of patients bypassing their local hospitals to seek care outside of their communities has identified the following determinates: hospital characteristics (size, ownership, distance and availability of hospital services), patient characteristics (age, gender, insurance, & severity of illness), and quality of care (patient perception of quality).

2.4.1. Hospital Determinates of Patient Bypass Behavior

The hospital characteristics size, ownership and distance have been identified as significant determinates of patient bypass [6-12].

Size

Hospital size is strongly associated with a patient's likely-hood to bypass [5, 8, 11, 12, 36]. Hospital size is measured by bed count [11, 36, 37]. Hospitals with higher bed counts are less likely to be bypassed [6, 38]. It is perceived that hospitals with more beds provide higher quality and have more service offerings [6, 10, 19]. A study by Sanders et al., (2015) found that patients who live in areas serviced by hospitals with few beds (8 to 15) have a higher propensity to bypass [11]. A study by Adams et al., (1991) evaluating rural patient selection of hospital , found that an increase of 10 beds, increases the likelihood a hospital is selected by 1.7 percent [6].

Ownership

It is established in the literature that ownership is a critical determinate of patient hospital choice [23, 37, 39-42]. Hospital ownership can be classified as government owned, public, private/for-profit, or private/nonprofit [5, 43]. The effects of ownership vary by patient group, diagnoses and residence [9, 40]. A study by Roh and Lee, (2006) of rural Medicare beneficiaries in California, found patients were 114.2 percent more likely to choose a nonprofit hospital than a public hospital [40]. A study by Escarce and Kapur, (2009) found that non-profit ownership increased the likelihood that a hospital was chosen among medical adult patients and children, but reduced it for surgical adult patients [5]. The

literature suggests that publicly owned hospitals are less likely to chosen by patients with private insurance because it is perceived that they primarily serve indigent populations and Medicare/Medicaid recipients [39, 41]. A study by Luft et al., (1990) conducted among patients undergoing one of seven surgical procedures in three geographically different areas of California, found that patients are more likely to bypass the nearest local hospital if it is publicly owned or for-profit [42]. Bronstein et al., (1991) found that rural pregnant women in Alabama were less likely to bypass the nearest rural hospital when it was publicly owned [37].

Distance

Many studies have demonstrated the value and influence of distance as a predictor of hospital choice [1, 6, 9, 11, 17, 37]. Patients that live in rural areas are more likely to travel outside of their community to receive perceived higher quality care [5, 37, 43]. Patients' willingness to travel is a factor in urban-rural disparities for many chronic diseases, including cancer, and is highly related to the severity of illness [34, 43]. Willingness to travel varies based on severity of illness, perceived quality and the distance to alternative hospitals [11, 17, 37, 42, 44, 45]. Many recent studies have found that propensity to bypass decreases with an increase in the distance to alternative hospitals [6, 17, 26, 34]. A study by Mohr et al., (2017) in rural sepsis patients, found that as distance to top decile (inpatient sepsis volume) hospitals increases the probability of rural hospital bypass decreases with a threshold of 20 miles. Another study, analyzing hospital choice among colon cancer patients in four Appalachian states, found that rural

residents were more likely to travel farther for high-volume hospitals with an average distance of 37.31 miles [43]. A study of Medicare beneficiaries (65 and older) found that they were more likely to travel outside of their primary care service area but, less likely to travel long distances [18]. A 2009 study among rural Californians found that urgent cases are less likely to bypass the facilities nearest their residence [5].

Availability of Hospital Services

Availability of hospital services is a determinate of a patient's choice to bypass local hospitals. The factors cited are lack of specialists, specialty care, advanced surgical procedures and technology [10, 16, 19, 20, 26, 46-48]. A study by Escarce and Kapur, (2009) found offering additional services and technologies would reduce rural hospital bypass [5]. Additionally, they identified access to time sensitive services, like trauma, obstetrics, and emergency care, are important to rural residents [5]. A study of bypass behavior in rural Kentucky cited that the lack of certain providers can cause patients to travel long distance for care and delay access to services; as service desirability increases, as does the likelihood of bypass [49]. A study of rural Medicare beneficiaries found dissatisfaction with the availability of services to be positively associated with bypassing the closest rural hospital [10]. A study by Weigel et al., (2018) investigating the effects of visiting surgical specialists on rural bypass, found communities with a local general surgeon were less likely to bypass than those with visiting surgeons except for ophthalmologists and orthopedic surgeons for elective surgeries [16].

2.4.2. Patient Characteristics

Age, sex, insurance and severity of illness are well-documented patient characteristics that are influential to understanding patient bypass behavior.

Age

Age is a well-documented determinate of patient bypass behavior and/or hospital choice [5, 6, 11, 19, 26, 34, 49, 50]. Studies have found that as age decreases propensity to bypass increases; elderly patients are less likely to bypass rural hospitals than younger patients are [6, 34, 50]. However, Roh and Moon (2005) found that older women are more likely to bypass local rural hospitals for obstetric care due to the potentially increased risk of complication [9]. A similar study by Liu et al., (2008) evaluating local primary care bypass, identified that patients 50-64 years old are significantly less likely to bypass local primary care than those 18-34 years old [11].

Sex

Sex is an established patient level predictor of bypass behavior [6, 10, 18, 20, 26, 43]. A study by Buczko (1992) found that women are less likely to bypass a local hospital than men [32]. Jintanakul and Otto (2009) had similar findings among rural Iowa residents, as did Tia et al., (2004) evaluating rural Medicare Beneficiaries [10, 26]. Cohen and Lee (1985) found that women are more likely to use a non-teaching hospital [51].

Insurance Status

The literature on bypass supports that insurance is an important determinate of bypass behavior [5, 9, 10, 19, 23, 34, 46]. Mohr et al., (2017)

found that rural residents who bypass local hospitals are more likely to have private/commercial insurance; even once restricted to patients under 65 who would not be eligible for Medicare [34]. Radcliff et al., (2003) found that patients with private insurance or managed care enrollees were more likely to bypass local rural hospitals [46]. A study by Roh and Moon (2005) found that Medicare beneficiaries are less likely to bypass local rural hospitals compared with those enrolled in managed care [9]. A study of bypass in rural California identified that uninsured patients and those with public insurance were less likely to bypass local rural hospitals than both adult and pediatric patients with private insurance [5].

Severity of Illness

Severity of illness is a consistent predictor, in the literature, of patient bypass behavior [6, 10, 11, 17-20]. Complexity of procedures and life-threatening illness have an impact on a patients choice of the nearest rural hospital [26]. A study by Weigel et al., (2018) found that patients with 2 or more chronic conditions and 4 or more diagnoses bypassed local hospitals for elective surgical procedures [16]. Adams et al., (1991) found that patients with severe illnesses have a greater propensity to choose larger urban and rural hospitals over small rural hospitals compared with less ill and well patients. Basu and Mobley (2007) identified that the disparity between severity of illness and travel distance is greater in rural than urban areas; travel distance increases with severity of illness [17].

2.4.3. Quality of Care & Patient Perception

There are six domains of quality as defined by the Institute of Medicine (IOM): safe, effective, patient-centered, timely, efficient, and equitable [52]. The disparity in quality of medical services, both perceived and actual, between rural and urban hospitals is a key determinate of patient bypass [6, 7, 9, 27, 49]. The literature on bypass behavior supports that patients are willing to travel further for "perceived" higher-quality care [11, 22, 36, 43]. Roh and Moon (2005) cited patient perception that public hospitals are designated to serve the indigent (poor, disadvantaged and/or uninsured) as a reason for bypass [9]. A study by Gooding (1999) suggest that local hospitals need to determine the quality related attributes that patients perceive to be lower in order to attract consumers and potentially take actions to improve [36]. The literature also supports that rural patients perceive their local hospitals as low quality across several domains [7]. A survey of rural Kentucky residents found that they are less likely to bypass a rural hospital if the perception of local quality was "excellent" [49].

2.5. Models of Patient Bypass Behavior

Several mathematical and conceptual frameworks have been established to empirically measure and describe and illustrate how hospital and patient characteristics influence patient bypass behavior. These models are foundational to understanding the impact of bypass behavior on rural hospital financial health. The following is a brief review of the major models.

2.5.1. Defining Geographic Markets for Hospital Care

Morrisey et al. (1988), was one of the first to explore bypass by analyzing hospital geographic markets to understand competition in the health care sector in the state of Nebraska [53]. They developed an empirical model using hospital discharge data to define hospital geographic markets in size (miles) and density for both rural and urban facilities.

2.5.2. Predicting Hospital Choice for Rural Medicare Beneficiaries

Adams et.al. (1991), examined hospital choice for Medicare beneficiaries and added severity/ complexity of illness to the literature as a major contributing factor to bypass. The premise for their analysis is based on the conceptual model that patients believe their providers, choose hospitals based on attractiveness (size, scope, etc.), patient need/illness and other enabling conditions. They also began to evaluate the impact of hospital closure on access to care, increase travel distance by an average of 20 miles [6].

Adams et.al. hypothesized that an individual's location of residence is a major determinate of hospital choice and those with similar characteristics will choose the closer of two "like" hospitals. This hypothesis was tested using maximum-likelihood estimates of a multinomial logit model to reduce bias and difficulties of a linear model.

2.5.3. Perceived Quality Choice and Perceived Value Choice Models

Gooding (1995) was one of the first to incorporate quality into a model for hospital choice [44]. The first segment of her two-part model describes how the hospital characteristics (level of technology, quality of staff, hospital size, service offerings, etc.) influence perceived quality of the local and alternative hospitals which impacts hospital choice. Hypothesizing that patients prefer hospitals with high perceived quality. Part

two adds the patient characteristics (travel time/distance and out of pocket cost) and illustrates how hospital characteristic influence perceived quality and patient characteristics influence sacrifice which determine perceived value. It hypothesizes that patients prefer hospitals with higher perceived value which is a factor of both perceived quality and sacrifice when considering local versus alternative hospitals. The study evaluated hospital bypass using a survey mailed to 500 respondents in Southern Illinois with a secondary follow-up survey to non-respondents.

2.5.4. Hospital Choice of Rural Medicare Beneficiaries

Tai et al. (2004), examined the patient, hospital attributes and the patient-physician relationship for hospital choice amongst rural Medicare beneficiaries [10]. This study built on the earlier work of Adams et al. (1991) and contributed additional patient-level determinates (socioeconomic status, health and functional status, access to primary care, etc.). The study used data from the Medicare Current Beneficiary Survey (MCBS), American Hospital Association (AHA) and data from the Medicare Hospital Service Area File. The conceptual model espoused that both patients and providers contribute to hospital choice and depicts that patients (or their providers) choose hospitals based on attractiveness (type, location, size, etc.) modified by patients' needs and preferences (patient-level determinates). The model was tested using a conditional logit model as deployed in prior studies [10].

2.5.5. A Conceptual Model of Rural Patient Hospital Choice

Roh and Moon, 2005, evaluated the underutilization of rural hospitals using comprehensive inpatient data from Colorado to examine the influence of the individual (patient) and institutional (hospital) characteristic on hospital choice [9]. Their model

suggests that cost of travel (distance and time), hospital characteristics (size, medical services, and ownership), and patient characteristics (medical condition, payment source and demography) are the major factors influential to hospital choice by rural patients.

2.5.6. The effects of agglomeration on interregional hospital patient flow

This study by Munn and Padgett (2013) examined the role of the local hospital as a regional exporter using a county-pair fixed effects spatial interaction model to analyze inpatient discharge data from the state of South Carolina [3]. The model evaluates the flow of patients from their county of residence, to the county of hospital discharge. The objective is to understand the agglomeration of healthcare services, flow of patients, and the relative size of an area's economy and its ability to export healthcare services.

This is a spatial interaction model, adpoted from the literature on trade, and it attempts to explain why the flow of patients between two counties is greater or less than the flow between any other two counties. The estimation assumes a negative bionmomial distribution with fixed effects. Counties with greater hospital capacity than residents were identified as net exporters of hospital services. Counties who's residents travel for health care services were identifed as net importers of medical care.

This work is most smiliar to to the current study, which evaluates bypass at the county level (Table 1). However, this Munn and Padgett study did not evaluate the factors contributing to patient migration and patient bypass behavior.

2.5.7. Determinates of bypass behavior for critical access hospitals

Ona et al. (2016), conducted a local study evaluating the determinates of patient bypass behavior for critical access hospitals (CAHs) in rural Kentucky [49]. The researchers conducted a literature review to identify the determinates of bypass and

developed a survey instrument to evaluate the determinates. The conceptual model proposes the quality of care (perception), hospital location, consumer traits and availability of services (severity of illness, technology and payment type) are the four major categories of determines of rural hospital patient bypass behavior. The model was tested using a logit model.

The study concluded that respondents were less likely to bypass the local hospital if travel time was important, preferred/desired services were available, local hospital quality was perceived to be excellent, local ambulance service was perceived fair, good or excellent, and local medical care was perceived good or excellent. Respondents were more likely to bypass if they perceived specialist in the neighboring county were good or excellent. Employed respondents and those with lower incomes were less likely to bypass their local CAH [49].

2.5.8. Rural Emergency Department or Top Decile Sepsis ED

Mohr et al., 2017, conducted a cohort study evaluating why adult, rural sepsis or septic shock patients bypass local hospital emergency departments for top-decile emergency departments using a logistic regression model [34]. The conceptual model depicts that a patient's decision on treatment setting (top decile sepsis volume ED or rural ED) for sepsis care, is influenced by the patient (demographics, comorbidities, severity of illness, insurance status and geography) and hospital determinates (location/distance, capabilities, and quality. The model also suggests that there may be a relationship between patient choice and mortality that needs further analysis as well as a direct association between the care experience received and mortality. Distance is treated an instrumental variable.

2.6. Impact on Rural Hospital Financial Health

Rural hospitals are disproportionally impacted by patient bypass [3, 5, 11, 14, 26, 49]. The primary results of bypass are reductions in occupancy rates, decrease in competitiveness, and loss of services ultimately leading to hospital closure [40]. Privately insured patients bypassing local/rural hospitals was found to be a major factor contributing to perceived low quality and erosion of the local hospital revenue base [14]. Tai et al., (2004) found that bypass places additional financial strain on fragile rural hospitals leading to reductions in services and closures, reducing access for vulnerable patient populations [10]. A study by Gujral and Basu, (2019) evaluating the effect of hospital closures on inpatient mortality in California, found that rural closures increase inpatient mortality by 5.9 percent and urban closures have no impact on mortality [33]. A study of interregional patient flow by Munn et al., (2013) found that the largest hospital exporters (large urban receiving hospitals) received substantial Medicare revenue from patients outside of the metropolitan area [3]. Liu et al., (2007) cited that smaller CAH's (8-15 beds) experience higher rates of bypass and are more vulnerable to closure [11]. Lawrence et al., (2003) cited low occupancy rates and out of market competition as the major reason for 46 percent of closures [54].

A 2007 study by Liu et al., surveying 647 adult patients of 25 CAHs found that 60% bypassed their local hospital for inpatient care [20]. The major contributing factors cited were access to specialty care, scope of service offerings and quality/reputation of local services and providers [21]. Patients with better access to transportation and financial resources (e.g., private insurance or other means to pay) regularly travel long

distance, outside of their communities, for perceived higher quality and greater service offerings [37]. A 2009 study by Escarce and Kapur found that vulnerable populations (e.g., older, without private insurance, urgent/emergent care needs) are more likely to receive care locally and are more impacted by rural hospital closures [5]. Ultimately, patient bypass behavior disproportionately impacts rural hospitals [5, 9, 27, 46].

A 2016 report by the National Rural Health Association (NRHA) indicated that 673 or one in three rural hospitals are at risk of closure and 210 are at extreme risk [31]. Since January 2010, 113 rural hospitals across the US have closed according to the North Carolina Rural Health Research Program (NC RHRP) [13]. Healthcare organizations are realizing the role, size and scale play on the ability to deliver higher quality care at lower costs [55]. The United States has witnessed a major uptick in hospital merger and acquisition activity, with 2017 being a record year of 115 transactions up 13% over prior years [13]. For-profit divestitures accounted for 32% of all transactions. 21% of all transactions were considered distressed [55]. While there were fewer transactions in 2018 (90), they were larger averaging $409 million in seller revenue [56].

The changing population demographic of rural America (high poverty, uninsured rates, high Medicare and Medicaid coverage and shrinking population) are major contributing factors to hospital closures [14]. The economic viability of a small rural hospital is dependent on its ability to attract a critical mass of patients to its facility. Many small, rural hospitals (<100 beds) are under financial pressure because they are unable to generate enough revenue to offset their expenses and yield a margin. Revenue is a product of payer mix (negotiated reimbursement rates) and patient volume [21]. The healthcare landscape is rapidly evolving, driven by policy and payer reform,

technological and scientific advancements, consumerism and the demand for price transparency. The increasing cost of healthcare services and reliance on expensive advanced technologies are leading to the consolidation or agglomeration of services to areas that can generate enough revenue to support the infrastructure [3].

In response to the changing healthcare landscape, many health care organizations are considering merger, affiliation or partnership to reduce the risk of closure [57]. To survive or thrive, hospitals and health systems must reduce fragmentation, have the size and scale to negotiate with payers and suppliers, and deliver exceptional quality and customer service. Larger organizations, like academic medical centers and health systems, are typically better positioned to take advantage of the opportunities presented by healthcare reform; however, there is a much steeper hill for community hospitals to climb if they want to remain independent and keep the doors open. The bottom line is rural hospitals must compete with larger, urban hospitals and academic health systems that are more suited to weather the changing health care landscape and have large service areas.

2.7. Conceptual Models of Financial Health

2.7.1. Effects of Rural Hospital Closure

Carroll (2019), evaluated the impacts of rural hospital closures on hospital quality and costs [15]. The study describes the role of hospital closure in improving efficiency or delaying treatment time and reducing health comes. Her conceptual model proposes that healthcare costs are impacted in three ways by hospital closures [15]. The first mechanism is allocative efficiency which increases if inefficient facilities close but

decreases if efficient hospitals close. Second, hospital closures make surviving hospitals more efficient due to increased market share to spread fixed costs. Third, hospital closure increases travel distances; increasing the cost of access and adversely impacting utilization.

2.7.2. Predicting Financial Distress and Rural Closure

Holmes, Kaufman and Pink (2017), developed the financial distress index which forecast rural hospital risk of closure based on both hospital and community characteristics [58]. Their conceptual model has 4 levels of risk that are associated with financial distress indicators (unprofitability, equity decline, insolvency, and closure). These events are influenced by financial performance, government reimbursement, organizational characteristic and market dynamics. The model was tested using data from the CMS Medicare cost reports, Provider of Service (POS) files and Nielsen-Claritas Population Facts (market data) using logistic regression.

2.8. Summary

The literature on patient bypass behavior has slowly grown between 1985 and 2019. Adams et al., (1991) identified most of what is currently understood about bypass behavior [19]. Subsequent studies have supported the initial determinates identified by Adams et al., (1991) [19]. Other studies of bypass have focused on hospital choice and been conducted primarily in Medicare beneficiaries. The literature has established that rural hospital closure exacerbates gaps in specialty care access [14]. Strategies that bring more specialty services, such as visiting-specialist services, telemedicine, Critical Access

Hospitals, etc., to rural locations could enhance both perceptions and actual quality of care and thus could mitigate patient bypass behavior [26].

Additional studies are needed to better understand the impact of rural hospital bypass behavior on hospital financial health. The current literature focuses on patient bypass or hospital choice as a contributor to decreased occupancy and ultimately closure [8, 23, 57] however, it does not seek to quantify the cost of bypass behavior and the determinates most influential to poor financial outcomes.

The current study is closely related to that of Munn et al., (2013) which focuses on interregional hospital patient flow and the role of hospitals as regional exporters [3]. However, this work expands upon and differs from Munn et al., (2013) in several specific ways [3].

Munn et al., (2013) only focuses on patient flow and the role of hospitals as regional exporters and does not examine the actual cost of patient migration [3]. This work will focus on regional patient flow and the regions, which serve as regional importers of healthcare services. A five region study by Nelson (2009) found that the largest regional exporters drive substantial revenue from Medicare beneficiaries outside of their metropolitan area [59]. This research seeks to understand interregional patient flow in the State of Florida, identifying the key determinates driving patient migration and the revenue associated with them. This will help rural hospitals identify the services that maybe needed to attract and retain patients and the financial benefits of doing so.

The primary aim of Munn et al, (2013) is to understand the economic impact of hospitals as regional exporters [3]. The study does not examine the determinates of

patient migration. This research aims to not only understand interregional patient flow but also to evaluate the determinates of bypass behavior associated.

The current studies aims will add to the literature on patient bypass behavior by evaluating the relationship between bypass behavior and rural hospital financial health for rural hospitals in the State of Florida.

3. METHODS

This chapter will review the study design, conceptual model, aims and hypotheses, data sources, study population and data set construction, and statistical analysis plan.

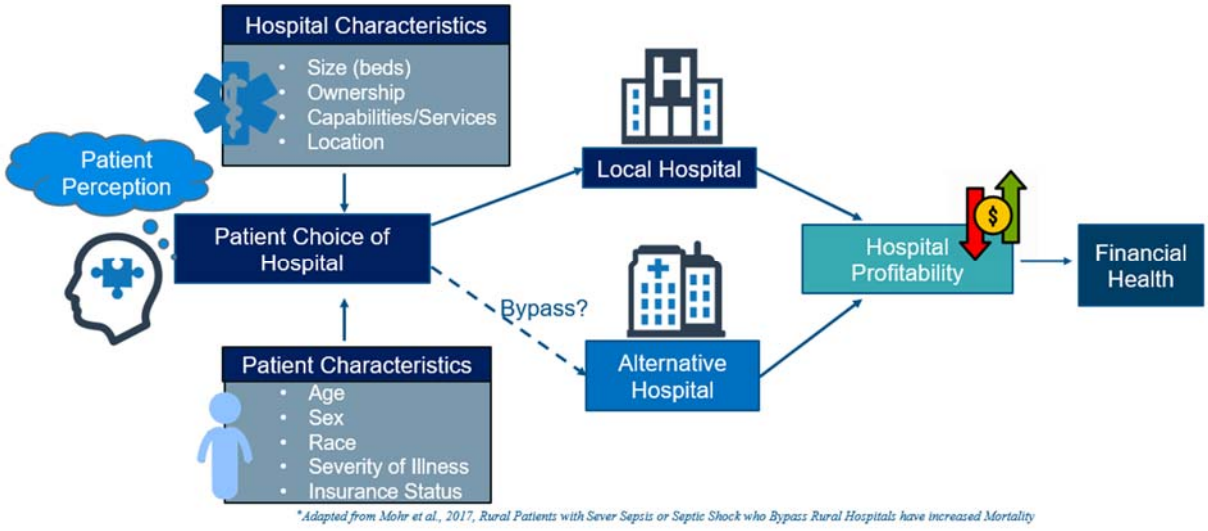
3.1. Study Design

This study used a retrospective cohort study design. The primary data sources are administrative data from the Healthcare Cost and Utilization Project (HCUP) Florida State Inpatient Database (SID), American Hospital Association (AHA) Information Technology (IT) Database and Healthcare Cost Report Information System (HCRIS). The study will examine patient bypass behavior and its impact on rural hospital financial indicators over a two-year period. The primary units of analysis are bypass hospital admissions (patient-level analysis), and patient's rural hospital bypass rate and hospital profitability (hospital-level analysis).

3.2. Conceptual Model

The following conceptual model (Figure 1, adapted from Mohr et al.,2017), illustrates that both patient-level and hospital-level characteristics influence patient hospital choice. The model depicts that a patient's choice of hospital (local or alternative) is impacted by both desired hospital characteristics and individual patient characteristics. The patient's choice to bypass contributes to a hospitals bypass rate, which ultimately impacts its overall financial health (profitability) of the entity.

Figure 1: Conceptual Model – Effects of Bypass Behavior on Financial Health



3.3. Specific Aim 1 Analysis Plan

3.3.1. Aim 1, Hypothesis and Research Question

This studies first aim was to describe patient bypass behavior for rural hospitals in the State of Florida. It asks the question, which patient characteristics are most associated with patients bypassing their local hospital? The hypothesis is that patient bypass behavior is described by patient characteristics and that patients that are male, younger, with lower severity of illness and private insurance are more likely to bypass a local hospital.

3.3.2. Data Source

Data for the analysis of aim 1 was sourced from the HCUP State Inpatient Database (SID) for the State of Florida. The SID was developed in partnership between the given states (49) and the Agency for Healthcare Research and Quality (AHRQ). It includes all patient-level discharge data from all community hospitals within a state. The

data file is uniform across states and includes all patients and payers (governmental, private insurance and uninsured) [60]. The SID contains clinical and non-clinical administrative data on all patients and as such was used to inform the patient-level and hospital-level determinates of patient bypass behavior.

3.3.3. Study Population and Dataset Construction

The study population was limited to all inpatient admissions to rural, non-federal, acute-care hospitals in the State of Florida from 2016 and 2017 for counties with only one hospital. All patients who were hospitalized in this time period and within these counties were eligible for inclusion. Exclusions included patients admitted to non-acute or special hospitals, long-term care hospitals and with point of origin for admission code 5, transferred from skilled nursing facility (SNF) or intermediate care facility (ICF), code 8, court/law enforcement order, E, transfer from ambulatory surgery center, and F, transfer from hospice. Patients missing sex, age, and insurance status were also excluded [19]. Hospitals were identified by their Medicare Provider Identification Number (Medicare Provider ID). Summary variables were constructed for the Charlson Comorbidity Score Index. Race and age were grouped into meaningful categories.

3.3.4. Measurement of Study Variables

Hospital admission outside of the patient's county of residence was the primary outcome measure for this aim and is defined as a patient's choice of hospital (Table 2). It evaluates if a patient chooses a local hospital, within their county of residence, or an alternative, outside of their home county. It is constructed by comparing the patient's county of residence to the county in which they are admitted. This variable was measured for every patient admission and treated as a dichotomous variable where 0 =

admission to a hospital within their county of residence (no bypass) and 1 = admission to an alternative hospital, outside of the county of residence (bypass).

The patient level descriptive covariates were provided by the SID. Sex was dichotomized where female = 1 and male=0. Age was analyzed as a discrete continuous numeric variable. Age was measured as both discrete and categorical, transforming it into four meaningful categories: pediatric, young adult, adult and elderly [12, 18, 26]. Race was transformed into four categories white, black, Hispanic and other. Insurance status was measured as a categorical variable with four levels: Medicare, Medicaid, private and uninsured/other. Income was measured by assigning the income quartile for the patients' home zip code. However, this variable was omitted from the models because of low variation across hospitals and many missing values.

The Charlson comorbidity index (CCI) and exposure variable, number of diagnoses, were used as proxies for severity/complexity of illness. The CCI categorizes comorbidities based on International Classification of Disease (ICD) – 10 codes [61]. Number of diagnoses was treated as a discrete variable [27].

Table 2: Aim 1 Study Variables

Primary Outcome Variable			
Variable	*Definition*	*Measurement*	*Source*
Bypass Hospital Admission	Patients hospital choice: local hospital or alternative hospital.	Dichotomous	SID
Predictor Variables			
Variable	*Definition*	*Measurement*	*Source*
Age	Indicating the patients age	Numeric – Discrete continuous	SID
Age	Categorizing patients age into four categories	Categorical	SID
Sex	Indicating the patient's sex	Dichotomous	SID
Race	Indicating the patient's race	Nominal (categorical)	SID
Number of Diagnoses	Indicates a patient's number of diagnoses – proxy for complexity of illness	Numeric - Discrete	SID
Comorbidities	Charlson Comorbidity Index	Numeric - Discrete	SID
Insurance Status	Indicating the primary payer in four categories	Nominal (categorical)	SID
Income	Identifies the income quartile for the patients' home zip code	Nominal (categorical)	SID
County of Residence	Identifies the patient county of origin or home county	Nominal	SID
County of Discharge	Identified the county a patient was discharged from	Nominal	SID

3.3.5. Statistical Analysis

Aim 1 of this study was to describe patient bypass behavior for rural hospitals in the State of Florida. Our hypothesis is patient bypass behavior is described by patient characteristics and patients that are male, younger, with lower severity of illness and private insurance are more likely to bypass a local hospital. This aim was evaluated

using a model based on a conditional logit model estimated by maximum likelihood, as a dichotomous outcome variable, bypass hospital admission. Patient bypass behavior was modeled using a set of independent variables to measure the impact of patient characteristics [6, 10, 27]. Like the original model, proposed by Adams et.al. 1991, this model considered that individuals make choices based on their own characteristics. The analysis was conducted in SAS Software version 9.4 [62].

Continuous study variables were described using means and standard deviations. Categorical variables were described using counts and percentages. Means were compared using an independent sample t-tests and chi-square statistics for proportions. Bi-variate analysis were conducted comparing each predictor to the primary outcome variable with a significance level of $\alpha < .05$. To ensure that no excessive correlation (collinearity) existed among the independent variables statistical tests including an examination of the correlation matrix, variance inflation factor (VIF), tolerance, eigenvalue and condition index were conducted [63]. Income quartile by zip code was dropped from the analysis due to a large amount of missing data.

The model building process started in SAS Software PROC Logistic by constructing the full model with all predictors included. Variables were then removed or added back into the model using a manual selection stepwise approach, based on their impact to the Akaike information criterion (AIC). The AIC is a measure of in-sample model fit and estimates the ability of a model to estimate future values; the lower the AIC the better the model fit [64]. This process was continued until the parsimonious model was identified. The parsimonious model was then modeled in SAS Software PROC GENMOD so that the effect sizes could be estimated as relative risks and within versus

between county variation could be accounted for using a county random effect model. A secondary analysis was conducted to evaluate the difference in Inpatient and Emergency Department bypass behavior using the same parsimonious model-building process.

3.4. Specific Aim 2 Analysis Plan

3.4.1. Aim 2, Hypothesis and Research Question

The second aim of this study was to determine which types of rural hospitals in the State of Florida may be most prone to patient bypass behavior. It was hypothesized that rural hospital bypass rate is impacted by hospital characteristics and hospitals that are publicly owned/non-profits, with smaller bed counts, and lower technical and telehealth capabilities will experience higher rates of bypass. This aim explores the research question, which hospitals characteristics are associated with higher rates of patient bypass?

3.4.2. Data Source

Data for this analysis was sourced from the HCUP SID for the State of Florida, as outlined in aim 1, the American Hospital Association (AHA) Annual Survey, Information Technology (IT) Database and the Medicare Cost Report, as outlined in aim 3 [65]. The AHA data set represents approximately 6,300 hospitals and includes demographics, utilization, expenses, organizational structures, operations, clinical delivery models, etc. The IT Database includes key indicators to gauge an organizations level of technology adoption and integration [66]. This data was used to understand effects of some of the hospital-level determinates like size (number of beds) and service offerings. The Medicare Cost Report was used to understand the additional hospital determinates such

as tax status and hospital type/designation. Medicare provider identification number served to link hospital data across the three data files.

3.4.3. Study Population and Dataset Construction

The study population was limited to rural, non-federal, acute-care and critical access hospitals in the State of Florida from 2016 and 2017 that are in counties with only one hospital. Non-acute, special hospitals and long-term care hospitals were excluded. The Three data sets used in this analysis were merged using Statistical Analysis System (SAS, Cary NC) version 9.4 based on the Medicare Provider ID number [62].

3.4.4. Measurement of Study Variables

The primary outcome measure was the annual bypass rates for 2016 and 2017 (defined based on the calendar year). Bypass rate was measured using data from the state inpatient database to evaluate patient flow. The measure was based on a numeric percentage calculated as illustrated in Figure 2. Bypass rates were calculated for all hospitals at the county level.

Figure 2: Calculating Bypass Rate

$$\left\{\frac{\text{(Total Originating County Patient Admissions – Within County Patient Admissions)}}{\text{Total Originating County Patient Admissions}}\right\} \text{X } 100$$

The hospital-level covariates were obtained from the SID, Medicare Cost Report and AHA data sets (Table 3). Hospital size (number of beds) was measured as both a discrete and a categorical variable and was transformed into the following categories: 0 = 25 or less, 1= 25-100 and 2= greater than 100. The variables used to measure service offerings are telehealth access and remote patient monitoring and were both

dichotomized. If these services were fully implemented or partially implemented, they were dichotomized with a 1 = access. If they were not implemented, then they received a 0 = no access. Tax status and hospital type were measured as dichotomous variables and dichotomized as non-profit = 0 and for-profit =1 and Acute Hospital = 0 and Critical Access Hospital = 1.

Table 3: Aim 2 Study Variables

Primary Outcome Variable			
Variable	*Definition*	*Measurement*	*Source*
Annual Hospital Bypass Rate	Number of admissions from non-home counties /total county admissions	Numeric (percent) - Continuous	SID
Predictor Variables			
Variable	*Definition*	*Measurement*	*Source*
Hospital Size	Indicating the size of a hospital based on number of beds	Nominal (categorical) and Discrete	AHA
Tax Status	Indicates the tax status of a hospital (non-profit or for-profit)	Dichotomous	Cost Report
Telehealth	Indicating if a hospital has access to telehealth services – measure of capabilities	Dichotomous	AHA
Hospital Type	Indicating if a hospital is critical access	Dichotomous	Cost Report
Remote Patient Monitoring	Indicating if a hospital has remote patient monitoring – measure of capabilities	Dichotomous	AHA
County	Identifies the county for which the bypass rate is described	Nominal	SID

3.4.5. Statistical Analysis

The goal of this aim is to determine what type of rural hospitals may be most prone to patient bypass behavior. I hypothesized that rural hospital bypass is impacted by hospital characteristics and hospitals that are publicly owned/ non-profits, with smaller

bed counts, lower technical and telehealth capabilities will experience higher rates of bypass. Bypass was measured as illustrated in Figure 3.

This aim was evaluated using a multivariable linear regression model to identify and describe hospitals with the highest rates of bypass by predictors including the hospital characteristics (size, services, tax status, telehealth and remote patient monitoring and hospital type).

Figure 3: Bypass Rate Regression Equation

$$\gamma_i = \beta_\theta + \beta_1 S_i + \beta_2 R_i + \beta_3 D_i + \beta_4 TX_i + \varepsilon_i$$

For the equation represented in Figure 3, Y*i* represents the dependent variable annual hospital bypass rate and *i* represents the hospital*; ß* represents the coefficients to be estimated*; S* represents hospital size*; R* represents remote patient monitoring; *D* represents hospital type or designation; *TX* represent tax status; *e* is the error term. Non-linearity of the relationship between the outcome and any predictors was assessed and transformed as indicated to allow for appropriate distributional form. All covariates remained in the model regardless of statistical significance.

The analysis was conducted using SAS Software (SAS, Cary NC) Version 9.4 [62]. Categorical variables were described using count and percentages. Multicollinearity was evaluated by examination of the correlation matrix, variance inflation factor (VIF), tolerance, eigenvalue and condition index and was not indicated. The full multivariable linear regression model, as outlined in Figure 3, was constructed in SAS considering the assumptions of linear regression (homoscedasticity, normality, linearity, and independence) were not violated. The model building process started in

SAS Software PROC REG by constructing the full model with all predictors included (Figure 3). Variables were then removed or added back into the model using a manual selection, stepwise, approach based on their impact to the Pearson's Correlation Coefficient (PCC) – r. PCC provides information about the magnitude of the association [67]. The parsimonious model was then modeled in SAS Software PROC GENMOD that the effect sizes could be estimates as rates and within versus between county variation could be controlled for using a county random effect (via a repeated statement).

3.5. Specific Aim 3 Analysis Plan

3.5.1. Aim 3, Hypothesis and Research Question

The third aim is to examine the association between rural hospital financial indicators and hospital-level bypass behavior in the State of Florida. Its hypothesis is that rural hospital financial health is impacted by patient bypass behavior and hospitals with high rates of patient bypass experience poorer financial performance. This aim seeks to explore the research question is rural hospital financial performance affected by patient bypass behavior.

3.5.2. Data Source

The data sources for aim 3 included the AHA IT Database, as outlined in aim 2, and the Medicare Provider Cost Report (Cost Report). The Cost Report consists of data submitted by most Medicare-certified providers (those who receive Medicare/Medicaid reimbursement) annually to the Centers for Medicare & Medicaid Services (CMS). The Cost Report contains utilization data, facility characteristics, cost and charges and financial statement data for all hospitals required to submit. CMS Cost Reports are

accessed via the Healthcare Provider Cost Reporting Information System (HCRIS) [65]. The Cost Reports were used to evaluate indicators of financial health.

3.5.3. Study Population and Dataset Construction

The study population was limited to rural, non-federal, acute-care hospitals in the State of Florida from 2016 and 2017 that are in counties with only one hospital. Non-acute, special hospitals and long-term care hospitals were excluded from this analysis.

3.5.4. Measurement of Study Variables

Hospital financial health is multidimensional [68]. As such, there is not a single indicator of financial health or profitability. This study evaluates two of the most common indicators, operating margin and total margin. The primary outcome variable (Table 4) was operating margin defined as the net income from patient care services. It is calculated as the difference between operating revenue (generated from patient care) and total expenses divided by operating revenue (Figure 4) [69]. As financial health is multidimension there were three secondary outcome measures used to evaluate this construct further: profit, net income per adjust discharge and total margin. Profit is a dichotomous indicator variable for positive operating margin. Net income per adjusted discharge is a scaled measure of operating margin. This measure was constructed to account for the variability in operating margin across hospitals by adjusting it by a measure of output or volume (adjusted discharges) [70]. Lastly, the final measure of financial health was total margin (Figure 4), measured as the difference between total net revenue (net revenue from all sources) and total expenses divided by total net revenue [69]. Total margin accounts for the fact that hospitals receive income (revenue) from sources other than services provided to patients such as: investments, state/governmental

appropriations, grants and philanthropy [69]. Total margin includes these other sources of revenue.

These four measures of profitability allowed us to understand the financial health of these hospitals, account for the fact that they receive revenue from sources other than services provided to patients and evaluate the association between bypass behavior and financial health. These indicators were only measured annually due to the frequency of cost report submission.

The financial covariates were identified in the SID and Cost Report and measured as outline in Table 4. The primary independent variable of interest was annual hospital bypass rate and was operationalized in two ways 1) as a numeric-continuous percent (Figure 2) and 2) as a dichotomous indicator variable of high-bypass rate. The indicator variable was constructed to evaluate the differences between hospitals with high (greater than 70%) and low (less and 70%) bypass [20].

Figure 4: Measures of financial health/profitability

(1) Operating Margin: $\frac{\text{Operating Revenue} - \text{Operating Cost}}{\text{Operating Revenue}}$

(1) Net Income Per Adjusted Discharge: $\frac{\text{Net income from Patient Care}}{\text{Adjusted Discharges}}$

(2) Total Margin: $\frac{\text{Total Revenue} - \text{Total Cost}}{\text{Total Revenue}}$

***Adjusted Discharges:** Number of discharges * Ratio (total gross charges/total gross inpatient revenue)

Table 4: Aim 3 Study Variables

Primary Outcome Variable			
Variable	*Definition*	*Measurement*	*Source*
Operating Margin	Net income from patient care services	Numeric (percent) Continuous	Cost Report
Secondary Outcome Variables			
Variable	*Definition*	*Measurement*	*Source*
Profit	Positive operating margin (net income from services to patients)	Dichotomous	Cost Report
Net Income Per Adjusted Discharge	Adjusted measure of operating margin scaled by adjusted discharges	Numeric (dollars) – Continuous	Cost Report
Total Margin	Net income from all activities	Numeric (percent) Continuous	Cost Report
Predictor Variables			
Variable	*Definition*	*Measurement*	*Source*
High Bypass	Indicator of high bypass rate in excess of 70%	Dichotomous	SID
Annual Hospital Bypass Rate	Number of admissions from non-home counties /total county admissions	Numeric (percent) Continuous	SID
Size	Indicating the size of a hospital based on number of beds	Nominal (categorical) and Discrete	AHA
Tax Status	Indicates the tax status of a hospital (non-profit or for-profit)	Dichotomous	SID
Remote Patient Monitoring	Indicating if a hospital has remote patient monitoring – measure of capabilities	Dichotomous	AHA
Hospital Type	Indicating if a hospital is critical access	Dichotomous	Cost Report
Adjusted Discharges	Number of discharges multiplied by the ratio of total gross charges to inpatient gross revenue	Numeric	Cost Report
Inpatient Cost to Charge Ratio	Ratio of inpatient cost to charges	Numeric (ratio)	SID
Emergency Department Cost to Charge Ratio	Ratio of emergency department cost to charges	Numeric (ratio)	SID

3.4.5. Statistical Analysis

The third and final aim was to examine the association between rural hospital financial indicators and hospital-level bypass behavior in the State of Florida. It was hypothesized that rural hospital financial health is impacted by patient bypass behavior and hospitals with high rates of patient bypass experience poorer financial performance.

The analysis was conducted using SAS Software (SAS, Cary NC) Version 9.4 [62]. All tests were two-sided and statistical significance was set at $\alpha=0.1$ for all models in aim 3 due to the small sample size. Categorical variables were described using counts and percentages and continuous variables were described using means and standard deviations. Multicollinearity was evaluated for each outcome variable by examination of the correlation (high when $r<0.8$), variance inflation factor (VIF), tolerance, eigenvalue and condition index and indicated a high level of collinearity between all covariates. As such multivariable models could not be used to examine the association of the independent variables (bypass rate, size, tax status, hospital type, adjusted discharges, and cost to charge ratios), collectively, on the dependent variables. Therefore, simple linear and logistic regression models were constructed to evaluate the association of the primary independent variable (bypass rate) on the dependent variables operating margin, profit, net income per adjusted discharge and total margin as depicted in the regression equation (Figure 5).

Figure 5: Financial health Regression Equations

$$\gamma_{om} = \beta_\theta + \beta_1 BR_i + \varepsilon_i$$

$$\gamma_{pf} = \beta_\theta + \beta_1 BR_i + \varepsilon_i$$

$$\gamma_{na} = \beta_\theta + \beta_1 BR_i + \varepsilon_i$$

$$\gamma_{tm} = \beta_\theta + \beta_1 BR_i + \varepsilon_i$$

For the equations represented in Figure 5 the dependent variables are represented as Y*om* represents operating margin, Y*pf* represents profit (positive operating margin), Y*na* represents net income per adjusted discharge and Y*tm* represents; ß represents the coefficients to be estimated*; BR* represents the hospital bypass rate; *e* is the error term.

Linear regression assumptions were checked using various statistical techniques including: Durbin Watson tests for auto correlation, Shapiro Wilk and Kolmogrov-smirnov test for normality, White test for heteroskedasticity, evaluation of the correlation matrix for multicollinearity and examination of distributions and residual plots for normality, linearity and homoscedasticity. Many of the outcome variables were found to violate these assumptions and thus were transformed by number line shifts (to greater than zero so that values could be logged) and log transformations allow for appropriate modeling.

The primary outcome variable, operating margin was shifted by 0.40 to allow for a log transformation and then multiplied by 100 to convert it to a percentage. The secondary outcome measure total margin was shifted by 0.076 and multiplied by 100 to convert it to a percentage. The resulting beta estimates for operating margin and total margin were then reverse transformed using the anti-log and the shifts were reversed

(subtracted from beta estimates) accordingly to allow for appropriate interpretation in the units of the outcome variable. The secondary outcome variable, net income per adjusted discharge was shifted by $2000 to allow for appropriate modeling. A logarithmic transformation was not indicated for this variable and the resulting beta estimates were reverse shifted (subtracted from beta estimates) to allow for appropriate interpretation. Lastly, the dichotomous outcome variable profit (positive operating margin) required a logarithmic transformation for appropriate modeling. The resulting beta estimates were reverse transformed using the anti-log and reported as relative risks.

3.5. Ethics Review

This study used de-identified, publicly reported data that is generated for public use. These data meet the criteria for Non-human Research specified by the Institutional Review Board (IRB) at the Medical University of South Carolina.

CHAPTER 4. RESULTS

This chapter presents the results of this study and are organized separately for each of its three aims beginning with a description of the study population for the aim.

4.1. Aim 1 Results

This studies first aim was to describe patient bypass behavior for rural hospitals in the State of Florida. I hypothesized that 1) patient bypass behavior is described by patient characteristics and 2) patients that are male, younger, with lower severity of illness and private insurance are more likely to bypass a local hospital. I also conducted a sensitivity analysis to evaluate the measurement of patient bypass behavior. They sensitivity analysis hypothesized that there is a difference between inpatient and emergency department patient bypass behavior. The primary unit of analysis was bypass hospital admissions.

4.1.1. Description of the Sample

The sample consisted of all inpatient admissions to non-federal, rural hospitals in the State of Florida for Counties with only one hospital. The analysis set contained hospital admissions, patient demographics, severity of illness and patient-level covariates for the years 2016 and 2017 from the HCUP SID for the State of Florida.

4.1.2 Hospital Inpatient Admissions

In 2016 there were 89,049 hospital inpatient admissions and in 2017 there were 91, 098 inpatient admissions to the rural hospitals included in this study. In total, there were 180,147 inpatient admission across both years. Among all admissions, 115,369 (64%) of patients bypassed the hospital in their county of residence and 64,778 (36%)

were admitted to the hospital in their county of residence. There was not a significant difference in bypass across years, as such this analysis was not be stratified by year ($p=0.55$). Table 5 depicts the descriptive characteristics for this sample.

We observed that 14.7% of the bypass group were pediatric (0-17), 51.1% young adults (18-34), 33% adults (34-64), and 37.2% were in the elderly (65+) category which, differed significantly with the non-bypass group which was composed of 2.9% pediatric, 6.8% young adults, 31.5% adults, and 58.8% elderly ($p<0.0001$). For those in the bypass group 76.2% were white, 11.7% black, 8.31% Hispanic, and 3.8% were of other races which differed significantly from the non-bypass group which was composed of 84.1% white, 9.9% black, 4.3% Hispanic, and 1.7% of other races ($p<0.0001$). Among patients in the bypass group 46.4% were male and 53.6% were female differing significantly from those in the non-bypass group where 44.9% were male and 55.2% were female ($p<0.0001$). The bypass group was composed of 44.2% Medicare, 24.1% Medicaid, 19.9% privately insured, 5.7% uninsured, and 6.1% with other funding sources which differed significantly with the non-bypass group which was composed of 66.8% Medicare, 12.1% Medicaid, 11.4% private insurance, 6.0% uninsured, and 3.7% with other funding sources ($p<0.0001$).

Individuals in the bypass group had a mean Charlson comorbidity index score of 1.2 which differed significantly from the non-bypass group that had a mean score of 1.8 ($p<0.0001$). The bypass group had a mean number of diagnosis of 11.2 which was significantly different from the non-bypass group which had a mean of 12.7 diagnoses ($p<0.0001$). The mean age of individuals in the bypass group was 49.8, differing significantly with the non-bypass group which had a mean age of 64.4 ($p<0.0001$).

In summary patients in the bypass group were primarily younger, white, female, with Medicare, and fewer comorbidities and diagnoses.

Table 5: Descriptive Characteristics of Sample between Bypass and Non-Bypass Groups

	Bypassed (N=115,369)	*Did Not Bypass* (N=64,778)	*P-value*
Year			
2016 Admissions	56,989 (64.0%)	32,087 (36.0%)	0.55
2017 Admissions	58,407 (64.1%)	32,269 (35.9%)	
Age Category			
Pediatric (0-17)	16,988 (14.7%)	1,864 (2.9%)	<0.0001
Young Adult (18-34)	17,422 (15.1%)	4,429 (6.8%)	
Adult (35-64)	38,088 (33.0%)	20,424 (31.5%)	
Elderly (65+)	42,898 (37.2%)	38,061 (58.8%)	
Race			
White	87,886 (76.2%)	54,461 (84.1%)	<0.0001
Black	13,536 (11.7%)	63,84 (9.9%)	
Hispanic	9,589 (8.31%)	2,803 (4.3%)	
Other	4,385 (3.8%)	1,130 (1.7%)	
Sex			<0.0001
Male	53,551 (46.4%)	29,049 (44.9%)	
Female	61,820 (53.6%)	35,727 (55.2%)	
Insurance			
Medicare	50,959 (44.2%)	43,277 (66.8%)	<0.0001
Medicaid	27,767 (24.1%)	7,858 (12.1%)	
Private	23,057 (19.9%)	7,400 (11.4%)	
Uninsured	6,596 (5.7%)	3,868 (6.0%)	
Other	7,017 (6.1%)	2,375 (3.7%)	
	Mean (± Std. Dev.)	Mean (± Std. Dev.)	
Charlson Comorbidity Score	1.2 (±1.8)	1.8 (±1.9)	<0.0001
Age	49.8 (±26.67)	64.4 (±20.7)	<0.0001
Number of Diagnoses	11.2 (±7.3)	12.7 (±6.6)	<0.0001

4.1.3. Multivariable Logistic Regression Model of Patient-Level Inpatient Bypass Behavior

Age group was a significant predictor of hospital bypass. After controlling for race, sex, CCI and insurance status, pediatric patients have 49% ($p<0.0001$) greater relative risk, young adults have a 35% ($p<0.0001$) greater risk and adult patients have a 14%($p<0.0001$) greater risk of bypass, when compared with elderly individuals (Table 6). The adjusted relative risk of bypass for female patients was 4% ($p<0.0001$) lower than males and was statistically significant (Table 6). Individuals within the "other" race group had a 14% ($p<0.0001$) increased adjusted risk of bypass when compared to white individuals. All other race categories did not have statistically significant differences in relative risk of bypass when comparted to whites (Table 6).

The measure of level of comorbidity used in this model was Charlson Score. Each 1 unit increase in the Charlson comorbidity score resulted in a 2% ($p=0.09$) decreased risk of bypass, however this finding was not statistically significant (Table 6). When compared to privately insured patients, those with Medicaid were at an 7% ($p=0.02$) decreased risk of bypass, patients with Medicare had a 13% ($p<0.0001$) significant decreased risk, and uninsured patient had a 17% ($p<0.0001$) decreased risk of bypass. Individuals with other payment sources did not differ in risk of bypass compared to those with private insurance (Table 6).

Table 6: Patient-Level Characteristics Associated with Risk of Rural Hospital Inpatient Bypass Behavior

Determinate	*Relative Risk*	*95% Confidence Interval*		*P-value*
Age				
Elderly (65+)	Ref.			
Pediatric (0-17)	1.49	1.26	1.78	<0.0001
Young Adult (18-34)	1.35	1.18	1.55	<0.0001
Adult (35-64)	1.14	1.08	1.20	<0.0001
Sex				
Male	Ref.			<0.0001
Female	0.96	0.95	0.97	
Race				
White	Ref.			
Black	1.04	0.94	1.13	0.46
Hispanic	1.11	0.95	1.30	0.20
Other	1.14	1.10	1.17	<0.0001
Charlson Comorbidity Index Score	0.98	0.97	1.0	0.09
Insurance Status				
Private Insurance	Ref.			
Medicaid	0.93	0.87	0.99	0.02
Medicare	0.87	0.82	0.92	<0.0001
Other	1.02	0.82	1.26	0.87
Uninsured	0.83	0.76	0.90	<0.0001
***Significant at the 0.05 level (2-tailed).*				

4.1.4. Hospital ED and Inpatient Admissions

In 2016 there were 395,567 hospital inpatient and ED admissions (total admission) and in 2017 there were 375,289 total admissions to the rural hospitals included in this sensitivity analysis. In total, there were 797,856 total admissions across both years. Among all patients 325,899 (41%) of patients bypassed the hospital in their county of residence and 471,957 (59%) were admitted to the hospital in their county of residence. There was a significant difference in bypass across years ($p<0.0001$). Among individuals who bypassed, 62.7% were inpatient admissions and 34.6% bypass for

emergency care which differed significantly with the non-bypass group who were composed of 37.3% inpatient admissions and 65.3% emergency department admissions ($p<0.0001$).

We observed that 22.2% of the bypass group were pediatrics (0-17), 23.9% young adults (18-34), 34.2% adults (34-64), and 22.2% were in the elderly (65+) category which differed significantly with the non-bypass group which was composed of 18.6% pediatrics, 23.6% young adults, 34.6% adults, and 23.3% elderly ($p<0.0001$). For those in the bypass group 73.8% were white, 13.6% black, 9.8% Hispanic, and 2.8% were of other races which differed significantly from the non-bypass group which was composed of 69.0% white, 18.6% black, 10.2% Hispanic, and 2.2% of other races ($p<0.0001$). Among patients in the bypass group 43.6% were male and 56.4% were female differing significantly from those in the non-bypass group where 42.4% were male and 57.6% were female ($p<0.0001$). The bypass group was composed of 27.6% Medicare, 32.6% Medicaid, 21.9% privately insured, 13.3% uninsured, and 4.3% with other funding sources which differed significantly with the non-bypass group which was composed of 29.1% Medicare, 33.4% Medicaid, 18.0% private insurance, 15.0% uninsured, and 4.4% with other funding sources ($p<0.0001$).

Individuals in the bypass group had a mean Charlson comorbidity index score of 0.61 which differed significantly from the non-bypass group what had a mean score of 0.47 ($p<0.0001$). The bypass group had a mean number of diagnosis of 6.1 which was significantly different from the non-bypass group which had a mean of 4.2 diagnoses ($p<0.0001$). The mean age of individuals in the bypass group was 41.1, differing significantly with the non-bypass group which had a mean age of 42.5 ($p<0.0001$).

In summary, individuals in this sample who were white, younger/adults, Medicaid beneficiaries with a higher number of diagnosis, larger Charlson score and seeking inpatient care were more likely to bypass (Table 7).

Table 7: Descriptive Characteristics for Patient-Level Predictors of Rural Hospital ED and Inpatient Bypass Behavior

	Bypassed (N=325,899)	*Did Not Bypass* (N=471,957)	*P-value*
Year			
2016 Admissions	162,628 (41.1%)	232,939 (58.9%)	<0.0001
2017 Admissions	136,271 (40.6%)	239,018 (59.1%)	
Admit Type (ED)			
Inpatient	109,094 (62.7%)	64,778 (37.3%)	<0.0001
Emergency Dept.	216,805 (34.6%)	407,179 (65.3%)	
Age			
Elderly (65+)	72,190 (22.2%)	110,015 (23.3%)	<0.0001
Pediatric (0-17)	64,410 (19.8%)	87,712 (18.6%)	
Young Adult (18-34)	77,857 (23.9%)	111,123 (23.6%)	
Adult (35-64)	111,442 (34.2%)	163,107 (34.6%)	
Race			
White	240,385 (73.8%)	325,673 (69.0%)	<0.0001
Black	44,463 (13.6%)	87,698 (18.6%)	
Hispanic	31,887 (9.8%)	48,258 (10.2%)	
Other	9,164 (2.8%)	10,328 (2.2%)	
Sex			
Male	141,956 (43.6%)	200,268 (42.4%)	<0.0001
Female	183,917 (56.4%)	271,687 (57.6%)	
Insurance			
Medicare	91,020 (27.9%)	137,513 (29.1%)	<0.0001
Medicaid	106,065 (32.6%)	157,656 (33.4%)	
Private	71,477 (21.9%)	85,102 (18.0%)	
Uninsured	43,394 (13.3%)	70,726 (15.0%)	
Other	13,943 (4.3%)	20,960 (4.4%)	
	Mean (± Std. Dev.)	Mean (± Std. Dev.)	
Charlson Comorbidity Score	0.61 (±1.3)	0.47 (±1.2)	<0.0001
Age	41.1 (±25.3)	42.5 (±25.2)	<0.0001
Number of Diagnoses	6.1 (±5.9)	4.2 (±4.6)	<0.0001

4.1.5. Multivariable Logistic Regression Model of Patient-Level Inpatient and ED Bypass Behavior

After controlling for age, race, sex, insurance status and comorbidities, patients have a 48% ($p<0.0001$) lower relative risk of bypass for emergency department admission (Table 8). Pediatric patients have a 30% ($p=0.0023$) greater risk of bypass, young adults have a 27% ($p=0.0069$) greater relative risk, and adult patients have a 15%($p=0.02$) greater risk of bypass, when compared with elderly individuals (Table 8). The adjusted relative risk of bypass for female patients was 2% ($p=0.01$) lower than males and was statistically significant (Table 8). When compared to white individuals the race categories black, Hispanic and "other" race groups did not a have statistically significant difference in relative risk of bypass (Table 8).

The measure of comorbidity used in this model was Charlson Score. Each 1 unit increase in the Charlson Score was not associated with a statically significant difference in relative risk of bypass (Table 8). When compared to privately insured patients, those with Medicaid have a 10% ($p=0.09$) lower risk of bypass, patients with Medicare have a 15% ($p=0.0023$) lower relative risk, and uninsured patients have a 10% ($p=0.03$) lower risk of bypass that differed significantly (Table 8). Individuals with other payment sources did not differ in risk of bypass compared to those with private insurance (Table 8).

Table 8: Logistic Regression Model for Patient Level Determinates of Risk of Rural Hospital Inpatient and ED Patient Bypass Behavior

Dependent Variable: Hospital Admissions				
Determinate	*Relative Risk*	*95% Confidence Interval*		*P-value*
Admission Type				
Inpatient	Ref.			
Emergency Department	0.52	0.38	0.069	<0.0001
Age				
Elderly (65+)	Ref.			
Pediatric (0-17)	1.30	1.10	1.54	0.0023
Young Adult (18-34)	1.27	1.07	1.51	0.0069
Adult (35-64)	1.15	1.02	1.29	0.02
Sex (Female)				
Male	Ref.			
Female	0.98	0.97	1.00	0.01
Race				
White	Ref.			
Black	0.82	0.61	1.10	0.19
Hispanic	0.95	0.72	1.24	0.68
Other	1.03	0.87	1.22	0.68
Charlson Comorbidity Index Score	0.99	0.96	1.03	0.92
Insurance Status				
Private Insurance	Ref.			
Medicaid	0.90	0.79	1.02	0.09
Medicare	0.85	0.77	0.94	0.0023
Other	0.89	0.75	1.05	0.15
Uninsured	0.90	0.82	0.99	0.03
***Significant at the 0.05 level (2-tailed).*				

4.2. Aim 2 Results

This studies second aim was to determine which types of rural hospitals may be most prone to patient bypass. It was hypothesized that rural hospital bypass is impacted by hospital characteristics and hospitals that are publicly owned/ non-profits, with smaller bed counts, lower technical and telehealth capabilities will experience higher rates of bypass.

4.2.1. Description of the Sample

The sample consisted of annual bypass rates for 2016 and 2017 from all non-federal, acute and critical access, rural hospitals in the State of Florida for Counties with only one hospital. The analysis set contained 12 hospitals that satisfied the inclusion criteria and included following variables: annual bypass rates, bed size, tele-health service indicator, remote patient monitoring indicator, tax status indicator and hospital type/designation indicator.

4.2.2. Annual Bypass Rates by County

There were hospitals from 12 counties included in this analysis. Each county had only one hospital and one observation for each year resulting in a total of 24 observations. Quarterly bypass rates were evaluated but showed no statistical significance (Figure 6). Table 9 depicts the characteristics for this sample as described in the following paragraphs.

Of the hospitals in this analysis 58.3% were general acute care and 41.7% were critical access. Among hospitals included in this analysis 50% had 0-25 bed, 33.3% had 25 – 100 beds, and 16.7% had 100 or more beds. As for hospital type, 58.3% were designated as general acute care hospitals compared to 41.7% that were designated as Critical Access Hospitals (CAHs).

In terms of ownership 58.3% were non-government owned, 33.3% were investor owned, and 8.3% were government owned but nonfederal (federal hospitals were excluded from this aim). Tax status distribution included 66.7% non-profit hospitals and 33.3% were for-profit facilities.

The measures of services offering included in this analysis were tele-health and remote patient monitoring. The sample included 83.3% of hospitals with access to tele-health while 16.7% did not. Half, (50%) of the hospitals had remote patient monitoring capabilities available. Lastly, the mean bypass rate was 72% with a range of 47 percentage points observed in the sample. Teaching status was dropped from this analysis as none of the hospital included had any level of teaching status.

In summary hospitals in this analysis were primarily acute care with 25-100 beds, non-governmental ownership, non-profit tax status, and telehealth with a mean bypass rate of 72%.

Figure 6: Quarterly Bypass Rates

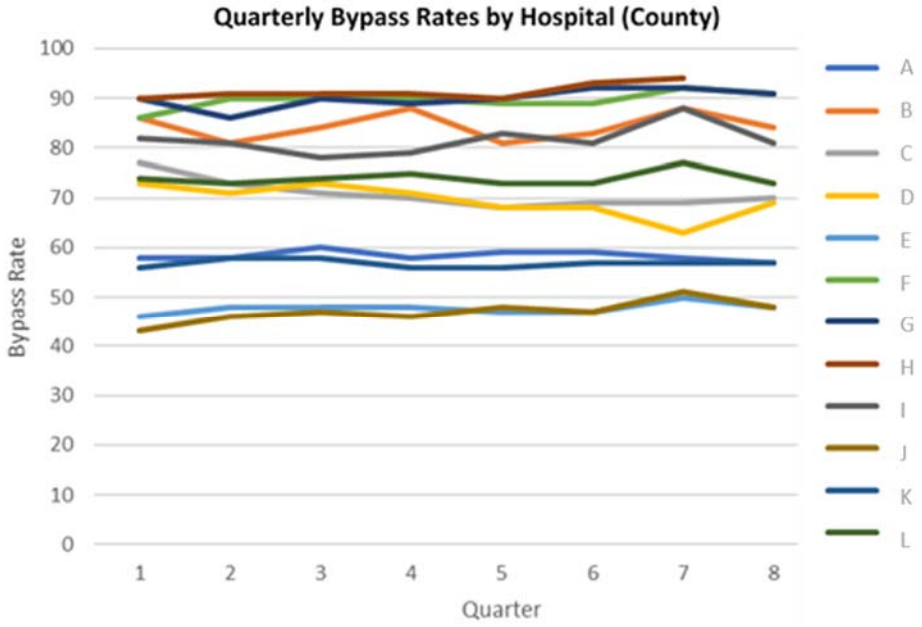


Table 9: Descriptive Characteristics for the Hospital-Level Predictors of Rural Hospital Bypass (12 hospitals for 2 years each)

	N= 24 (%)
Hospital Type (Designation)	
Acute Care	14 (58.3%)
Critical Access	10 (41.7%)
Hospital Size (Beds)	
0-25	12 (50%)
25-100	8 (33.3%)
100 +	4 (16.7%)
Owner	
Non-Government	14 (58.3%)
Investor-Owned	8 (33.3%)
Government, Non-Federal	2 (8.3%)
Tax Status	
Non-Profit	16 (66.7%)
For-Profit	8 (33.3%)
Telehealth	
Tele	20 (83.3%)
No Tele	4 (16.7%)
Remote Patient Monitoring	
RPM	12 (50%)
No RPM	12 (50%)

4.2.3. Hospital Characteristics Associated with Inpatient Hospital Bypass Rates

The multivariable model of hospital characteristics associated with bypass rate (in percentage) included the independent variables: hospital type, beds (categorical), tax status, and remote patient monitoring (Table 10).

Hospital bed count (hospital size) significantly impacted hospital bypass rate. When compared to hospitals with 0-25 beds, those with 26-100 beds experienced 12.1% (p=0.05) lower bypass rates and those with greater than 100 beds experienced rates that were 23.3% (p=0.008) higher (Table 10). Remote patient monitoring was not statistically significant in the model however having remote patient monitoring capabilities was associated with a 6.35% (p=0.32) decrease in bypass rate (Table 10). Having the tax

status of for profit, compared with non-profit, was associated with 8.42% (p=0.29) increase in bypass rate, but was not statistically significant (Table 10). Lastly, Critical Access Hospital designation was associated with a statistically significant 14.8% (p<0.0001) increase in bypass rate (Table 10).

Table 10: Hospital Characteristics Associated with Rural Hospital Bypass Behavior

Determinate	*Parameter estimate*	*95% Confidence Interval*		*P-value*
Hospital Size (Beds)				
0-25 Beds	Ref.			
26-100 Beds	-12.1%	-24.3	.14	0.05
>100 Beds	-23.3%	-40.5	-6.11	0.008
Hospital Type (Designation)				
Acute Care	Ref.			
Critical Access	14.8%	10.2	19.3	<0.0001
Remote Patient Monitoring (RPM)				
No RPM	Ref.			
RPM	-6.35%	-18.8	6.15	0.32
Tax Status				
Non-Profit	Ref.			
For-Profit	8.42%	-7.18	24.0	0.29
***Significant at the 0.05 level (2-tailed).*				

4.3. Aim 3 Results

The third aim was to examine the association between rural hospital financial indicators and hospital-level bypass behavior in the State of Florida. It was hypothesized that rural hospital financial health is impacted by patient bypass behavior and hospitals with higher rates of patient bypass experience poorer financial performance.

4.3.1. Description of the Sample

The sample consisted of all non-federal, acute care, rural hospitals in the State of Florida for counties with only one hospital for the years 2016 and 2017. The analysis set

contained 12 hospitals that satisfied the inclusion criteria, resulting in 24 total observations. The following dependent variables were assessed in separate models: operating margin, an indicator variable for positive operating margin, net income per adjusted discharge, and total margin. The primary independent variable of interest was annual bypass rates (as a percentage), or an indicator variable for high bypass rate. Other covariates tested included: adjusted discharges, cost to charge ratios, bed size, remote patient monitoring indicator, tax status indicator, and hospital type/designation indicator.

4.3.2. Hospital Financial Health

Hospitals from 12 counties were included in this analysis. Each county had only one hospital and one observation for each year (2016 and 2017); for a total of 24 observations. Twelve hospitals (50%) had a positive operating margin and twelve (50%) had a negative operating margin. Variation in total margin and operating margin varied greatly by bypass rates across hospitals as shown in Figure 7. Table 11 depicts the characteristics for this sample as described in the following paragraphs.

We observed that 66.7% of those in the positive operating margin group had low (<70%) bypass rates and 33.3% had high (>70%) bypass rates which differed significantly from the negative operating margin group were 16.7% had low bypass rates and 83.3% had high rates of bypass (p=0.01). Among hospitals with a positive operating margin 83.3% were acute care and 16.7% were critical access which differed significantly from those with a negative operating margin were 33.3% were acute care and 66.7% were critical access (p=0.01). The positive margin group was comprised of 16.7% hospitals with 0-25 beds, 58.3% with 26-100 beds, and 25% with greater than 100

beds which significantly differed from the negative margin group were 83.3% had 0-25 beds, 8.3% had 26-100 beds, and 8.3% had greater than 100 beds ($p=0.0044$).

Of the hospitals with a positive operating margin, 41.7% were non-profit and 58.3% were for-profit differing from those with a negative operating margin where 91.7% were non-profit and 8.3% were for-profit ($p=0.0094$). We observed that 91.7% of hospitals with a positive margin had remote patient monitoring and 9.3% did not, which was significantly different from the negative operating margin group where 8.3% had RPM and 91.7% did not ($p<0.0001$).

Observations with positive operating margin had a mean bypass rate of 63.1% (±15.7) which was significantly different from those with a negative operating margin having a 80.6% (±10.6) mean bypass rate ($p<0.0001$). Hospitals with a positive operating margin had a mean 10,943 (±6,188) adjusted discharges which was significantly different from hospital with a negative margin which had a mean of 4,693 (±4,847) adjusted discharges ($p<0.0001$). The mean Medicare inpatient cost to charge ratio of observations with a positive operating margin was 0.32 (±0.14) which was significantly different from the negative margin group 0.46 (±0.11) ($p<.0001$). Lastly, we observed a mean Medicare emergency department cost to charge ratio of 0.13 (±0.05) in the positive operating margin group and a mean ED cost of charge ratio of .017 (±0.04) in the negative margin group which were significant different ($p<0.0001$).

In summary, hospitals with lower bypass rates, larger bed counts, remote patient monitoring, a significantly higher number of adjusted discharges and lower cost to charge ratios were more likely to have positive operating margins.

Figure 7: Mean Operating and Total Margin by Bypass Rates

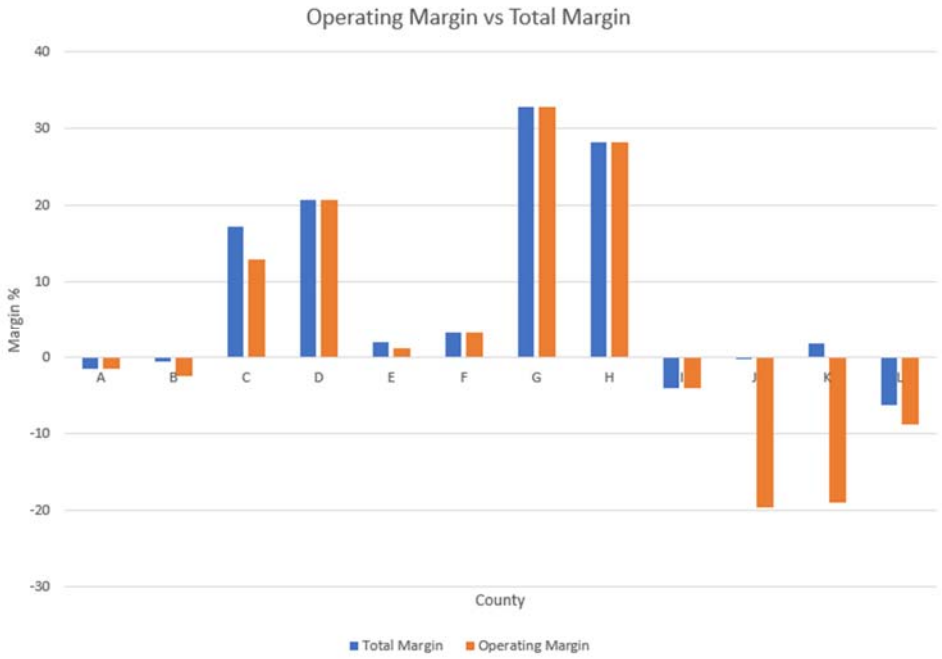


Table 11: Descriptive Statistics between Hospitals with Positive and Negative Operating Margins

	Positive Operating Margin (N=12)	Negative Operating Margin (N=12)	*P-Value*
Bypass Level			
Low (<70%)	8(66.7%)	2 (16.7%)	0.01
High (>70%)	4 (33.3%)	10 (83.3%)	
Hospital Type (Designation)			
Acute Care	10(83.3%)	4 (33.3%)	0.01
Critical Access	2 (16.7%)	8 (66.7%)	
Hospital Size (Beds)			
0-25	2 (16.7%)	10 (83.3%)	0.0044
26-100	7 (58.3%)	1 (8.3%)	
>100	3 (25%)	1 (8.3%)	
Tax Status			
Non-Profit	5 (41.7%)	11 (91.7%)	0.0094
For-Profit	7 (58.3%)	1 (8.3%)	
Remote Patient Monitoring			
No RPM	1 (8.3%)	11 (91.7%)	<0.0001
RPM	11 (91.7%)	1 (8.3%)	
	Mean (± Std. Dev.)	*Mean (± Std. Dev.)*	
Bypass Rate (%)	63.1 (±15.7)	80.6 (±10.6)	<0.0001
Adjusted Discharges	10,943 (±6188)	4,693(±4847)	<0.0001
Medicare Inpatient Cost to Charge Ratio	0.32 (±.014)	0.46 (±0.11)	<0.0001
Medicare Emergency Department Cost to Charge Ratio	0.13 (±0.05)	0.17 (±0.04)	<0.0001

4.3.3. Association between Operating Margin and Bypass Behavior

The parsimonious model for the primary outcome variable, hospital operating margin was a simple linear regression model containing only the primary independent variable annual hospital bypass rate, due to limitations in the data. Operating margin is

reported as a percentage and not a rate. The results, depicted in Table 12, suggest that for each 10% increase in bypass rate operating margin decreases by 39.2% (p=0.08).

Table 12: Association of Bypass Rate with Hospital Operating Margin

Determinate	*Parameter estimate*	*90% Confidence Interval*		*P-value*
Bypass Rate in 10% increments	-39.2%	-44%	-34.3%	0.08
***Significant at the 0.10 level (2-tailed).*				

4.3.4. Profit (Dichotomous Negative/Positive Operating Margin) and Bypass Behavior

The parsimonious model, evaluating profit or positive operating margin, was a simple logistic regression model. This model regressed bypass rate against the dichotomous outcome profit (positive operating margin). The results, depicted in Table 13, suggest that as bypass rate increases by 10% the relative risk of a hospital having a positive operating margin (being profitable) decreases by 30%. This was a statistically significant finding (p=0.01).

Table 13: Association of Bypass Rate with Profit (Dichotomous Negative/Positive Operating Margin)

Determinate	*Parameter estimate*	*90% Confidence Interval*		*P-value*
Bypass Rate in 10% increments	0.70	0.52	0.93	0.01
***Significant at the 0.10 level (2-tailed).*				

4.3.5. Net Income Per Adjusted Discharge and Bypass Behavior

A simple linear regression model was fitted using a normal distribution and log transformation to evaluate the relationship between net income per adjusted discharge and patient bypass rate. This model regressed bypass rate against the outcome variable.

The results, depicted in Table 14, suggest that for each 10% increase in bypass rate, net income from patient care services decreases by $232 per adjusted discharge. This finding did not reach statistical significance.

Table 14: Association of Bypass Rate with Net Income Per Adjusted Discharge

Determinate	*Parameter estimate*	*90% Confidence Interval*		*P-value*
Bypass Rate in 10% increments	-$232	-$1012	$547	0.62
***Significant at the 0.10 level (2-tailed).*				

4.3.6. Association between Total Margin and Bypass Behavior

The parsimonious model for the primary outcome variable, total margin was a simple linear regression model containing only the primary independent variable bypass rate regressed against the secondary outcome variable total margin. Total margin is reported as a percentage and not a rate. The results, depicted in Table 15, suggest that for each 10% increase in bypass rate total margin decreases by 6.8% (p=0.01).

Table 15: Association of Bypass Rate with Total Margin

Determinate	*Parameter estimate*	*90% Confidence Interval*		*P-value*
Bypass Rate in 10% increments	-6.8%	-7.02%	-6.55	0.10
***Significant at the 0.10 level (2-tailed).*				

CHAPTER 5. DISCUSSION

This study examined the impact of patient bypass behavior on rural hospital financial health for rural hospitals in the State of Florida in the years 2016 and 2017. The analysis was conducted to examine three aims. The major findings are discussed separately for each aim.

5.1. Aim 1 Discussion

Aim 1 was to *describe rural patient bypass behavior.* There were statistically significant differences between the patient-level characteristics of rural patients who bypassed (bypassers) compared to rural patients who did not bypass (non-bypassers). These differences were consistent with the established literature and support the hypotheses that patient bypass behavior is impacted by patient and hospital characteristics and patients that are male, younger, with lower severity of illness and private insurance are more likely to bypass a local hospital [6, 10, 11, 19, 20, 26, 49, 71].

5.1.1.1. Association between Age and Patient Bypass

The results of this analyst found age to be a significant predictor of patient bypass behavior and that younger patients were at a greater risk of bypass. The literature supports that the propensity to bypass decreases with advancing age [6, 34, 50]. Pediatric patients have 5% greater risk of bypassing local hospitals than adult patients. The literature suggest that pediatric procedures require, or are perceived to require, specialists that are not typically available at rural hospitals as a possible explanation [27]. It should also be noted that pediatric patients are not typically the decision makers for where they receive care. Additionally, it is established in the literature that rural hospitals

and emergency departments often lack pediatricians, pediatric intensivists as well the equipment and supplies necessary to care for pediatric patients [72-75]. Only 3% of pediatric intensivists practice in rural areas [73]. Many U.S. hospitals without adequate pediatric care or protocols for consultation routinely transfer these patients to distant facilities [72]. Telehealth may be a mechanism to address the access disparity for pediatric patients and help keep them in their local communities.

5.1.1.2. Comorbidities and Patient Bypass

Comorbidities were measured using the Charlson comorbidity index. The results for this population were not statistically significant at alpha<.05; however, would be considered marginal at alpha<.10. Additional analysis is needed to better understand this relationship. It is established that illness severity is a consistent predictor of travel for rural patients [46]. The literature supports that older individuals typically have greater severities of illness and comorbidities and are unwilling to travel long distances for treatment; they prefer local care [6, 19, 35]. Most of the patients in this analysis were in the elderly group, comprising 45% of the total sample. Table 5 supports the observation that elderly patient in this sample did not bypass. Elderly patients comprised 37.2% of the bypass group and 58.8% of the group that did not bypass which was significantly different ($p<0.0001$). A study by Basu and Mobley suggests that high quality community resources and adequate access to primary care are factors that can decrease bypass for more complex patients and allow them to receive care locally [17, 18]. Additional studies should evaluate the level of primary care available to this patient population.

5.1.1.3. Association between Sex and Patient Bypass

The analysis of sex for this population is consistent with the established literature. Females are at a lower risk of bypass (more likely to use local hospitals) than males. One study reported that women favor non-teaching hospitals which, although not part of this analysis, suggests that rural hospital should target their marketing efforts and tailoring their service offerings towards women [51]. It is suggested that the demographic structure of rural communities is skewed towards single elderly women which may also contribute to this phenomenon [26].

5.1.1.4. Insurance Status and Patient Bypass

The results for the patient bypass behavior determinant insurance status for this population are consistent with the literature although our findings were not statistically significant. Individuals with public insurance, Medicare, 2% and Medicaid 8%, have lower risk of bypass compared to those with private insurance. However ever, those with other payment sources (i.e. self-pay) were at a 12% increased risk of bypass compared to those with private insurance. In fact, relative risk of bypass increased with "quality" of payment source (Medicaid, Medicare, other and Private). Alternatively, the literature reports higher rates of retention among those with Medicaid and Medicare, a consistent finding when compared to those with private or other insurance [16, 27]. Additionally, it is established that rural hospital payer mix substantially differs from urban hospitals as it is more likely to have a higher percentage of uninsured patients and those with public insurance, these findings are consistent [10, 19, 46]. Rural residents employed in urban market, with employee sponsored insurance plans, are more likely to have limitations in hospital choice causing them to not be able to receive care locally [18, 43, 46].

5.1.1.5. Sensitivity Analysis

The results of the sensitivity analysis for the measurement of bypass behavior, which is traditionally inpatient admission only, were in support of the traditional measurement and the established literature [6, 10, 19]. Bypass for this population had a significantly 48% (P<.0001) decrease in risk of bypass for emergency department care. Suggesting that patients prefer to stay local for emergency care but, bypass for inpatient admissions. Based on the results of the sensitivity analysis rural hospitals are vital resource for emergency care. Hospitals under financial pressure should consider conversion to free standing emergency departments with a small number of observation beds. Policy studies should evaluate the role of critical access designation and should consider alternative mechanism to keep care local.

5.1.2. Aim 1 Limitations

A major limitation of this analysis is that it uses archival billing data which was not collected for research purposes and may be subject to limitations due to the accuracy of coding. However, administrative bills are a very clear indicator of the actual utilization for a patient population and are used for research purposes in other works. This analysis only evaluated two years of data for one state. However, the sample size was large, there were no significant difference in results for the years, and the level of significance among predictors was high and consistent with the established literature. Additionally, this analysis was at the county level and only evaluated rural counties with one hospital. This was done to align with aims two and three which are hospital level analyses. Income was not included in the final model due to a large amount of missing

observations. Lastly, we were unable to evaluate patient perceptions of hospital quality due to the limitations of the dataset.

5.1.3. Aim 1 Conclusion

The predictors of patient bypass behavior among single hospital rural counties in the State of Florida are consistent with and supported by the established literature. It is important for rural hospitals to evaluate how to best manage patient bypass behavior. Mechanisms which might be most helpful include the implementation of telehealth as well as programs focused on women and children. Telehealth is well supported in the literature on bypass as a mechanism for increasing access to specialty care in rural communities [14, 26, 29]. Thus, allowing patients to receive high quality, specialty and subspecialty care and remain in their local communities. If rural hospitals in the State of Florida decide to implement telehealth interventions, they should first consider targeted programs for women and pediatric patients. Based on this analysis women are less likely to bypass, and pediatric patients were much more likely than or adults to bypass. As such, hospitals wishing to regain market share should consider implementing special programs, i.e. obstetrics, which may help to attract and retain some of these patients. Additionally, hospitals should direct their marketing efforts toward females, the primary healthcare decision makers [76], and privately insured patients who are more likely to bypass [5]. Future studies should consider the needs of pediatric patients, women and underrepresented minorities.

5.2. Aim 2 Discussion

Aim 2 was to *determine which types of rural hospitals in the State of Florida may be most prone to patient bypass behavior*. The results of the linear regression model were somewhat consistent with the literature and in support of the hypothesis that rural hospital bypass is impacted by hospital characteristics and hospitals that are publicly owned/ non-profits, with smaller bed counts, lower technical and telehealth capabilities will experience higher rates of bypass.

5.2.1.1. Association Between Hospital Size (Number of Beds) and Bypass Behavior

The results of this analyst found hospital size, measured as number of beds, was a significant predictor of patient bypass behavior and that hospitals with smaller bed counts experience higher rates of bypass. Hospitals that had more than 100 beds had bypass rates that were 23.3% lower than those with 25 or less. This was one of the most significant findings of this analysis; as the majority of rural hospital in the US have fewer than 100 beds [5]. This finding is consistent with the literature on bypass that patients prefer hospitals with more beds [5, 6, 9, 10, 23]. Adams et.al. identified that patients associate number of beds with better quality healthcare and a small increase of only 10 beds increased hospital choice by 1.7% [6, 19]. Liu et.al. found that as critical access hospital bed size increased patients had lower odds of bypassing local primary care [11]. As such future studies should further explore the downstream impact of inpatient bypass on local primary care utilization.

5.2.1.2. Remote Patient Monitoring and Bypass Behavior

Remote patient monitoring (RPM) was used as measure of capability/ service offering. The findings of this analysis are in support of the hypothesis that hospitals with

less or lower service offerings will experience higher rates of patient bypass behavior [9, 43, 77]. The results for remote patient monitoring were consistent with the literature that advanced service offerings decrease bypass but were not statistically significant in our sample. Hospitals with remote patient monitoring (RPM) experienced lower rates of bypass (6.35% lower). Telehealth was excluded from this analysis due to a limitation in the data set that did not allow for the construction of a meaningful measure that could distinguish between various modalities of telehealth (e.g. store and forward versus video visit) or the scale of the telehealth service. Additionally, telehealth was not rare in this population. Ten out of the 12 hospitals in this sample had access to telehealth whereas only six had RPM. Secondly, RPM is more patient centered application of telehealth that uses technology to collect and transmit health information from patients to health care providers as part of a treatment plan. It allows healthcare providers to monitor and engage with patients who have chronic conditions are may be considered high risk. As such, RPM has demonstrated the ability to aid in the early detection of illness, reduce number and cost of hospitalizations and improve quality of life [71, 78]. The literature on bypass reports that specialty applications of telehealth have been associated with improved local access to higher levels of care. Our findings support this relationship. However, the literature also notes that lack of reimbursement is a barrier to implementation, making it important to design tele-health payment policy to minimize this barrier for rural hospitals [14].

5.2.1.3. Association Between Hospital Type (Designation) and Bypass Behavior

The results for critical access hospital designation were significant. Critical access hospitals (CAHs) experienced bypass rates that were 14.8 % higher than non-

designated hospitals. The survival of small hospitals depend on their ability to generate enough revenue to cover costs; high rates of bypass do not help. The CAH designation was created to strength the financial health of vulnerable rural hospital as such, CAHs receive cost-based reimbursement for both inpatient and outpatient services provided to Medicare beneficiaries [79]. The literature suggest that critical access hospitals might be at a substantial risk of closure if federal program funding was removed and policies should be aimed at increasing the number or CAHs [18, 29]. Only 10 of the 12 hospitals with less than 25 beds was a CAH. In order for an acute hospital to be designated critical access it must have no more than 25 inpatient beds meet two criteria: 1) be at least 15 miles by secondary road and 2) at least 35 miles by primary road from the nearest hospital [14]. It should also be noted that CAH's typically have less service offering than non-designated rural hospitals and larger urban hospitals [34].

5.2.1.4. Tax Status and Bypass Behavior

The results for the hospital level bypass behavior determinant tax status for this population are somewhat consistent with the literature. However, these results were not in support of the hypothesis that non-profit hospitals experience higher bypass rates. This study found that a for-profit tax status was associated with bypass rates that were 8.42% higher than non-profit. This finding was not statistically significant. The literature on tax status, which is often used as a proxy for ownership, is somewhat mixed. While studies have found this determinant to be critical to patient choice, its influence varies based on the population [6, 19, 37, 42]. A study by Luft et.al, conducted in California, found that patients had a strong preference for private hospitals as opposed to public and non-profit hospitals [42]. It is believed that patients associate non-profit, small hospitals, with lower

quality and capability when compared to for-profit hospitals [9, 40]. However, a second study by Escarce and Kapur, also conducted in California, found mixed results. They show that general medical adult and pediatric patients were more likely to choose non-profit hospitals when compared to surgical adult patients [5]. Additional studies are needed to better understand this phenomenon and the role of patient perception.

5.2.2. Aim 2 Limitations

The major limitation of this analysis was a small sample size with only twelve hospital each with two observations (one per year). The initially analysis plan was to evaluate quarterly bypass rates however there were not statistically significant differences in quarterly bypass rates (Figure 6), therefore the analysis was modified to evaluate annual bypass rates for the years 2016 and 2017. There were originally thirteen hospitals included in this analysis, however, upon further review one was a specialty hand hospital and not eligible for inclusion. Additionally, there was also a small number of predictors included in the model due to the limitations of the sample and or data set. Teaching status was removed from the analysis as none of the hospital had any level of teaching designation. Ownership was removed from this analysis because there were too few observations in each category. Once dichotomized into private versus public ownership it was consistent with the tax status variable as tax status is often used in place of ownership. Also, we were unable to control for health system affiliation (if a rural hospital was owned by or affiliated with a larger health system). Distance (travel distance to alternative hospitals) was not included in the analysis but is cited in the literature as a major determine of hospital bypass. Future studies should evaluate its impact on bypass for this population.

Additionally, the construction of the telehealth variable into meaningful categories for analysis was a major limitation. The data source simply reported if an organization had fully, partially or not implemented telehealth with no distinctions in level of service offerings or utilization. Future research is needed to advance the measurement of telehealth utilization to allow for meaningful analysis. Lastly, this analysis used archival billing data which was not collected for research purposes and may be subject to limitations due to the accuracy of coding.

5.2.3. Aim 2 Conclusion

This analysis concluded that there are two major hospital level determinant that drive patient bypass for the rural Florida hospitals included in this analysis, hospital size and critical access hospital designation. The results for hospital size are consistent with the literature. However, the results for telehealth and RPM represent a new contribution to the literature on bypass.

Hospital size demonstrated significance as a determinant of bypass. However, size is not an easily modifiable characteristic and hospitals should explore other options, such as advanced applications of telehealth, to attract patients. Although this study found that CAHs have higher bypass rates, further studies should be conducted to understand the impact of critical access designation on overall financial health for vulnerable hospitals. It may be more advantageous for rural hospitals with high bypass to consider CAH designation than to increase the number of beds. Additional studies should also evaluate the major inpatient services that are “leaking out” of these rural communities to aid hospitals in enriching their service offerings.

The determinants of rural emergency department (ED) bypass should also be evaluated in comparison to inpatient to aid in resource planning. The average inpatient bypass rate for this population was 72% with 5 of the 12 hospitals having rates in excess of 80%. As such many of these hospitals may be solely surviving based on ED volume and federal funding from CAH designation. Additionally, studies should further evaluate advanced applications telehealth and their role in reducing inpatient bypass.

5.3. Aim 3 Discussion

Aim 3 was to *examine the association between rural hospital financial indicators and hospital-level bypass behavior in the State of Florida.* Bypass behavior, measured as bypass rate, was a marginally significant predictor of the primary outcome variable operating margin ($p=0.07$) and secondary outcome variable total margin ($p=0.10$). There was also a statistically significant ($p=0.01$) association between bypass rate and positive operating margin (profit) however; its association with net income per adjusted discharge was not statistically significant ($p=0.62$). These findings were in support of the hypothesis that rural hospital financial health is impacted by patient bypass behavior and hospitals with higher rates of patient bypass experience poorer financial performance. However, the small sample size imposed great limitations on statistically power, and the use of a cross-sectional design meant that we were not able to establish causality between bypass rates and financial measures. As such we can neither reject or fail to reject the null hypothesis.

5.3.1.1. Association of Operating Margin and Profit with Bypass Behavior

The findings for operating margin and profit or having a positive operating margin were in support of the hypothesis. While only marginally significant, these finding had exceptional magnitude. Rural, community hospitals have revenue streams that are consistently under attack from many directions and, typically operate on very slim or narrow margins [80]. In 2016 the average community hospital in the United States earned a 6.7% operating margin a decline of 0.7% from 2015 [81]. An article from the Healthcare Financial Management Association found that hospital operating margins declined by 21% in between 2018 and 2019 [82]. A more recent brief from Kaufman-Hall's (KH) National Hospital Flash Report suggests that average hospital operating margins have dropped 2% year over year, detrimentally affecting non-profit hospitals [83]. KH suggests that large scale volume and revenue losses may be to blame. The findings from this analysis suggests patient bypass behavior may account for some of the variation in operating margin at a stark decrease of 39.2% for each 10% increase in bypass rate. This analysis also suggests that as bypass rate increase by 10% the relative risk of having a positive margin decreases by 30%.

5.3.1.2. Association between Total Margin and Bypass Behavior

Total margin accounts for net income from all sources including patient services, investments, state/governmental appropriations, philanthropy, etc. while operating margin is only net income from patient care services [81]. In comparison to operating margin (6.7 % in 2016), the average US hospital total margin was 7.8% in 2016 compared to 7.9% in 2015 [81], decrease of 0.1%. While also marginally significant our analysis of the association between bypass rate and total margin showed that as bypass

rate increases by 10% total margin decreases by 6.8%. The results of this analysis indicate that bypass behavior impacts both total margin and operating margin. While the effect may not be as great on total margin, it is still negatively impacted by bypass behavior. This is an important finding as many community hospitals derive substantial portions of their income from services other than patient care [69]. Figure 7, comparing the average total margin and operating margin, depicts the deviation in these values and provides additional justification for utilizing multiple financial outcome measures in this analysis.

5.3.1.3. Net Income Per Adjusted Discharge and Bypass Behavior

Net income per adjusted discharge is a scaled measure of operating income. This measure was used to compare the effect of bypass behavior across hospitals in dollars as opposed to a percent. Additionally, it recognizes that net income care vary widely across hospitals and geographic markets [68]. The results of this analysis were not statistically significant but indicate a substantial magnitude with net income per adjusted patient discharge decreasing by $232 for each 10% increase in bypass rate. In 2013 only 2.5% of US hospitals earned more than $2475 per adjusted discharge [68]. Based on this analysis a 10% increase in patient bypass behavior would decrease net income per adjusted discharge to only $2,243. This finding further illustrates how sensitive operating income is to patient volume.

5.3.2. Limitations

The major limitation of this analysis was it sample size. The small sample size did not allow for sufficient statistical power to conduct a multivariable regression model as initially planned. While the beta estimates for bypass rates in all models were large

the amount of variance explained by the models was small. Indicating that these models explained very little of the variability across hospitals. With a larger sample we may have been able to add covariates to control for other factors known to affect financial measures.

Many of the planned covariates (size, tax status, teaching status, etc.) which have been established in the literature as determinants of hospital financial health could not be included in the model due to a high level of multicollinearity with the primary independent variable, bypass rate [68]. Also, while building these models many of the planned covariates muted the effect of the primary independent variable, a further limitation of the sample size. These factors limited the ability to conduct a multivariable analysis. Furthermore, the healthcare cost data did not naturally fit a normal distribution requiring scaling and transforming for it to be modeled. Further, the cross-sectional study design with only two years of data does not allow us to make casual inferences.

It is of note that this analysis was conducted using archival billing data which was not collected for research purposes and may be subject to limitations due to the accuracy of coding and consistency in data collection.

5.3.3. Aim 3 Conclusion

Many studies have examined the determinants of bypass behavior and described bypass for various patient populations. Our results support the previous findings and adds two important additional insights. First, our finding of a potential association between bypass behavior and financial performance is a new and important. This exploratory analysis, while marginally statistically significant, suggest that bypass rate may have a large effect on hospital indicators of financial health, and that this effect may differ for

the type of financial measure used. Suggesting that for rural hospital in our data, bypass rate may be contributing to poor financial performance, and that some hospitals rely greatly on non-patient income for financial health, and these income sources may be essential for their ability to keep their doors open.

One in three rural hospitals are at risk of closure due to increasing financial pressures and the inability to attract patients [13]. More than half of all rural hospital closures since 2010 were in the South [14]. The financial stability of a hospital is dependent upon its ability to attract a critical mass of patients to its facility[14]. Rural, community hospital, provide access to vital healthcare resources for many of the nation's most vulnerable populations [79].

These finding may have substantial health policy implications as rural hospitals are disproportionately affected by changes in federal reimbursement and state level Medicaid rate reductions [14]. Future studies should be conducted with a larger sample size i.e. all rural hospitals in 10 to 12 states, to provide the statistical power required to control for covariates and demonstrate a clear relationship between bypass behavior and indicator of financial health. Future studies should also evaluate the impact of CAH designation on financial health as conversion to a [79]. An important future design issue is related to assuring that future studies use designs that will allow us to make causal inference about the effect of bypass on financial health. Thus, researchers should consider examining bypass rates for larger samples, over more years, and potentially lagging the bypass measure, to examine how previous years bypass rates affect future years financial indicators.

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