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The Association of Rural Hospital Closures with In-Hospital and 30-Day Post Hospital Discharge Mortality from Emergency Care Sensitive Conditions

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THE ASSOCIATION OF RURAL HOSPITAL CLOSURES WITH IN-HOSPITAL AND 30-DAY POST HOSPITAL DISCHARGE MORTALITY FROM EMERGENCY CARE SENSITIVE CONDITIONS

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DEDICATION

This work is dedicated to the strong women who raised me to be stubborn in the pursuit of my dreams while holding steadfast to my roots. These roots connect me to Gratio, a farming community in rural northwest Tennessee where my maternal grandmother was raised, and to Bexar, in the hills of rural northwest Alabama where my paternal grandmother was from. It was not a conscious effort, but somehow their love of their homelands built up in me a love of rural people and places. My mother, raised in an area known as Spout Springs in rural northwest Tennessee, cultivated this love in such a way as for me to make it my lifelong affair. These three women unknowingly gave me the premise for my life's work, and the personal sacrifices they made ultimately facilitated my ability to succeed, including the achievement of this milestone in my journey.

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ABSTRACT

Purpose

Over 100 rural hospitals have closed in the U.S. since 2010. Continuous pressures on the rural health care delivery system suggest that the trajectory of closures will continue in at least the short-term. While the causes of rural hospital closures have been described in the literature, the effects on the health outcomes of populations that experience these closures are still poorly understood. The purpose of this study was to determine associations between rural hospital closures and in-hospital and 30-day post hospital discharge mortality rates for affected residents experiencing time-sensitive emergencies in two U.S. states.

Methods

Rural hospital closures were identified using a national dataset provided by The Cecil G. Sheps Center for Health Services Research at the University of North Carolina at Chapel Hill. Counties where closures occurred were matched to comparison counties, both with and without hospitals. Secondary data for all counties were obtained from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project and a statewide all-payer claims database to include patient encounters from hospital inpatient and Emergency Department records for a five-year period. These records were selected for those that included at least one of four Emergency Care Sensitive Conditions (ECSCs): acute myocardial infarction, stroke, sepsis, or trauma. Variations in in-hospital and 30-day post hospital discharge mortality from pre-closure to post-closure time periods were assessed using a difference-in-difference-in-difference study design.

Results

In-hospital mortality associated with ECSCs was 8.2% in the pre-closure time period and 4.1% post-closure. For residents living in counties where closures occurred, in-hospital mortality declined more rapidly in the post-closure time period compared to residents living in other counties. This overall decline occurred despite a marked increase in in-hospital mortality in the first quarter after the closure compared to the two previous quarters. This initial surge in in-hospital mortality suggests delays in access to treatment for ECSCs immediately post-closure. Thirty-day post hospital discharge mortality associated with ECSCs (one state only) was 7.8% in the pre-closure time period and 8.0% post-closure. For residents of the closure county only, the 30-day post hospital discharge mortality rate slowed significantly in the time period following the closure. This suggests increased access to higher quality care in the aftermath of the closure but may also indicate that some residents chose not to seek care at all.

Conclusions

In-hospital and 30-day post hospital discharge mortality are both associated with rural hospital closures. Together, these associations are inconclusive in that they suggest either potential delays in care or increased access to higher quality care post rural hospital closure. Further studies are needed to better describe the relationship between rural hospital closures and mortality.

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CHAPTER 1

INTRODUCTION

Rural populations in the United States (U.S.) are known to suffer poorer health outcomes as compared to their urban counterparts (Meit et al., 2014). This geographic disparity is receiving new attention as research now shows pronounced, divergent trends between rural and urban areas in terms of all-cause, cause-specific, premature, and even in-hospital mortality rates (Hoffman & Holmes, 2017; James, 2014; Mansfield, Wilson, Kobrinski, & Mitchell, 1999; Singh & Siahpush, 2014; Villapiano, Iwashyna, & Davis, 2017). A recent study conducted by the Centers for Disease Control and Prevention on the leading causes of death in the U.S. shows that, annually, rural areas experience higher age-adjusted death rates from the leading five conditions than urban areas (Moy et al., 2017). Further, minority rural populations, especially African Americans, experience two to three times greater risk for mortality compared to rural and urban white and urban African-American counterparts and have the highest rates of premature death in rural counties (Henning-Smith, Hernandez, Ramirez, Hardeman, & Kozhimannil, 2019; Singh & Siahpush, 2014). There also appear to be regional differences, with communities in the Southeast U.S. experiencing higher rates of mortality, which are reported to be related to race and poverty (Hoffman & Holmes, 2017; James, 2014; Mansfield et al., 1999).

It is unclear what the specific cause of the rural mortality disparity is; however, it is well-known that rural populations, due to the demographic, socio-economic, cultural, and environmental characteristics of their communities, struggle to maintain access to necessary services such as health care (Henderson & Taylor, 2003; T. L. Thomas, Diclemente, & Snell, 2014). Rural populations are typically older, poorer, sicker and live in places that are isolated and have low population densities (Arcury, Preisser, Gesler, & Powers, 2004; Meit et al., 2014; Mullner, Rydman, Whiteis, & Rich, 1989). In addition, unemployment is often a challenge while jobs that are available are sometimes in hazardous industries (Mullner et al., 1989). As a result of these characteristics, rural populations must often travel long distances to access needed services and/or jobs, and adequate transportation to reach these destinations is a known barrier (Arcury et al., 2004; Henderson & Taylor, 2003).

With respect to access to health care, several studies have found that increased distance to health care reduces utilization and delays access to timely care (Arcury et al., 2004; Basu, 2005; Buchmueller, Jacobson, & Wold, 2006; Carr, Branas, & Metlay, 2009; Henderson & Taylor, 2003; Hsia, Kanzaria, et al., 2012; Nemet & Bailey, 2000). Patients choose health care services for convenience and to minimize travel costs (Buchmueller et al., 2006; Nugent, 2000; Succi, Lee, & Alexander, 1997). This is especially true among older adults, who face additional challenges traveling in general (Basu, 2005; Fleming, Williamson Jr., Hicks, & Rife, 1995; Nemet & Bailey, 2000; Premkumar, Jones, & Orazem, 2016; Reif, DesHarnais, & Bernard, 1999). Research conducted with a population of older male rural patients seeking services through the Veterans Administration expressed a preference for obtaining surgical care as locally as possible, even with the knowledge of increased mortality risks at local facilities (Finlayson, Birkmeyer, Tosteson, & Nease, 1999). Other studies have demonstrated that women, the uninsured, and members of racial and ethnic minority groups also have preferred to receive care locally in spite of compelling reasons to travel for care (Basu, 2005; Nugent, 2000; Premkumar et al., 2016).

For rural populations, the preference for local health care is inextricably linked to their attachment to community (Gifford & Mullner, 1988; Nemet & Bailey, 2000). Attachment to community is so strong that it impacts migration patterns of rural populations: even during economic downturns and in light of growing community concerns, people choose to stay where there is familiarity (Ulrich-Schad, Henly, & Safford, 2013). Community identity is also tied to local institutions, such as the local hospital, which itself is not only a source of health care services but also a source of hope (Gifford & Mullner, 1988). Hospitals, like other businesses, are susceptible to changes in the economic stability of a rural community (Cordes, 1989). Unfortunately, the recent Great Recession of the late 2000s and early 2010s severely impacted the economic stability of rural areas all across the U.S. (Holmes, Kaufman, & Pink, 2016).

Thus, despite these preferences for local care in one's own community, the U.S. is currently experiencing a disturbing trend of a rising number of closures of community hospitals in rural areas (Kaufman, Thomas, et al., 2016). According to the Cecil G. Sheps Center for Health Services Research at The University of North Carolina at Chapel Hill, since 2010, over 100 rural community hospitals have closed out of approximately 2,200 total nationwide (Sheps Center, 2019). These closures increase the distance rural populations must travel to receive health care services, which may be complicated by limited access to emergency specialty care and capability of emergency medical services (Moy et al., 2017). Interventions for time-sensitive illnesses such as heart attacks or unintentional injuries that are treatable but subject to the "golden hour" (that is, the sooner the intervention, the better the overall outcome) are subject to increased travel times to definitive care (JEMS, 2012).

This trend of rural hospital closures has also been associated with the passage of the Patient Protection and Affordable Care Act (ACA), specifically as it relates to the expansion of the Medicaid benefit (Bastain, Garner, Barron, Akowuah, & Mase, 2016; Kaufman, Reiter, Pink, & Holmes, 2016; Lindrooth, Perraillon, Hardy, & Tung, 2018). Among U.S. states that chose not to expand these benefits ("non-expansion" states), the number of rural hospital closures is higher (Bastain et al., 2016; Lindrooth et al., 2018). Compared to expansion states, rural hospitals in non-expansion states were less profitable and provided more uncompensated care to those who are uninsured or underinsured; non-expansion states also averaged more rural hospitals overall (Kaufman, Reiter, et al., 2016; Lindrooth et al., 2018). Given the number of states that did not expand coverage to Medicaid and pressures at the hospital level including an unfavorable reimbursement environment and existing financial distress due to a weakened economy, the trend of rural hospital closures nationally is likely to continue, at least in the short-term (Holmes et al., 2016; S. R. Thomas, Holmes, & Pink, 2016). Publicly owned rural hospitals and/or those experiencing the greatest financial pressure (especially in the South, Midwest, and Northeast) are most at risk for future closure (Kaufman, Thomas, et al., 2016; Pink, Thompson, Howard, & Holmes, 2018).

Decreased access to health care services in rural populations is expected to directly contribute to negative health outcomes, especially among older adults, those in poverty, and among racial and ethnic minority groups (Bastain et al., 2016; Basu & Cooper, 2000; Bindman, Keane, & Lurie, 1990; Ly, Jha, & Epstein, 2011). The demographic, socio-economic, and environmental challenges of living in rural areas referenced before are expected to be exacerbated by hospital closures (Reif et al., 1999). A qualitative study conducted among older adults that experienced hospital closure reported that the new logistical and cost challenges presented by accessing care in a different location were too much of a burden; so much so that many "just didn't bother" with attempting to access needed health care services, impacting the mental health of many affected (Countouris, Gilmore, & Yonas, 2014).

Although one may anticipate expected associations in health outcomes due to rural hospital closures based on these studies, there is very little in the literature that specifically links rural hospital closures to health outcomes, especially mortality, among rural populations. Due to the increased distance and travel times to reach services, mortality from illnesses that are time-sensitive (otherwise known as emergency care sensitive conditions) may increase, thereby further intensifying the geographic disparities in health outcomes between rural and urban populations in the U.S. Thus, the aim of this study was to determine the association of rural hospital closures with in-hospital and 30-day post hospital discharge mortality from selected emergency care sensitive conditions (ECSCs). Two U.S. states with hospital closures during the past decade were the targets for secondary data analyses. The study's specific research questions were as follows:

1. Examining all ECSC encounters as a group, is there a difference in in-hospital mortality during ECSC encounters for residents living in rural counties that experienced a hospital closure compared to residents living in rural counties that did not experience a hospital closure?

2. Does a difference in in-hospital mortality associated with rural hospital closure vary among specific ECSC diagnoses?

3. Is there an overall difference in 30-day post hospital discharge mortality associated with ECSC encounters for residents living in a rural county that experienced a hospital closure compared to residents living in rural counties that did not experience a hospital closure?

CHAPTER 2

LITERATURE REVIEW

Rural Hospitals

The availability of health care services in rural U.S. communities has evolved over the past 75 years. The prioritization of construction of modern hospitals in rural and underserved areas after World War II, through the Hospital Survey and Construction Act of 1946 (more commonly known as the Hill-Burton Act), resulted in nearly half of the nation's hospitals being located in rural areas by the mid 1980s (Clark, Field, Koontz, & Koontz, 1980; Ermann, 1990; Kisacky, 2019).

In general, rural hospitals are smaller, with fewer beds and an overall lower occupancy rate; operating on thin margins more dependent on public payment sources such as Medicare; organized as a non-profit; and housed in older facilities (Kaufman, Reiter, et al., 2016; Rohrer, 1989). They are also constrained by higher costs per unit on supplies and staff as well as difficulty in recruiting and retaining their staff and forming strategic partnerships (Henderson & Taylor, 2003; Mick & Morlock, 1990). Uncertainty in the quantity and quality of care available is a common perception of rural hospitals (Rohrer, 1989). However, rural hospitals are often one of the largest employers in their county and provide enhanced value to their communities beyond that of just providing health care services (Harmata & Bogue, 1997; Henderson & Taylor, 2003; Mullner & McNeil, 1986; Mullner et al., 1989; D. Williams, Hadley, & Pettengill, 1992).

While the intent of the Hill-Burton Act was to redistribute the supply of hospital beds in a more equitable fashion across the U.S., the end result was an oversupply of hospital beds in certain areas due to the lack of physician redistribution (Clark et al., 1980). This oversupply is thought to have increased overall costs to the health care system due to staffing and maintenance requirements and unnecessary utilization, which then resulted in further regulation and standardization by the Federal government in the 1970s (Shepard, 1983).

After the U.S. experienced a major economic recession in the 1970s, the first reports of hospital closures began to surface (Mayer, Kohlenberg, Sieferman, & Rosenblatt, 1987; Moscovice, 1989; Premkumar et al., 2016). An early report suggested that perhaps the Hill-Burton Act had gone too far, resulting in weaker institutions both financially as well as potentially in terms of quality of care provided (Mayer et al., 1987). Today, half of all hospitals in the U.S. are located in rural areas (approximately 2,250), representing 16% of inpatient hospital beds (United States Government Accountability Office (GAO), 2018). The majority of rural hospitals are located in the Southern U.S. (Freeman, Howard, Randolph, & Holmes, 2015).

Rural Hospital Closures: Summary

During the 1970s, 148 rural hospitals were reported to close, followed by approximately 250 in the 1980s (Mayer et al., 1987; Muus, Ludtke, & Gibbens, 1995). During this time period, the vast majority of hospital closures were located in urban areas; however, during the mid 1980s, this rapidly flipped and by 1989 there were two rural hospitals closing for every one urban (Friedman, 1990; Mick & Morlock, 1990; D. Williams et al., 1992). This wave of closures in the late 1980s and 1990s resulted in

Federal legislation that created new funding mechanisms for rural hospitals, such as cost-based reimbursement through the Critical Access Hospital program, that helped to mitigate the closure crisis at that time (Friedman, 1990; Kaufman, Thomas, et al., 2016; Ricketts, 2000).

As a result, rural hospital closures in the 1990s slowed, with only 208 closing (United States Department of Health and Human Services (DHHS) Office of Inspector General (OIG), 2003). From 2010-2014, 47 rural hospital closures occurred, with the rate doubling from 2011-2012 to 2013-2014 (Kaufman, Thomas, et al., 2016). During the period from 2013-2017, 64 rural hospitals closed, which was higher than the number of urban hospitals that closed (49) and the number of rural hospitals that opened (3) during the same time period (United States GAO, 2018). As of July 2018, 85 rural community hospitals closed since 2010 (Sheps Center, 2018). By June 2019, this number was 106 (Sheps Center, 2019).

In general, most rural hospitals that close may be described as having similar characteristics: they are small, have low occupancy rates, are in a for-profit ownership structure, provide fewer services, have low Medicare and/or Medicaid volumes, are located in a competitive market, have smaller market shares, experience financial stress, are serving a declining population base, are located near another hospital, have aging facilities, and are not accredited (Buchmueller et al., 2006; Gardiner, Oswald, & Jahera, 1996; Gifford & Mullner, 1988; Longo & Chase, 1984; Mayer et al., 1987; Mick & Morlock, 1990; Mullner & McNeil, 1986; Rosenbach & Dayhoff, 1995; S. R. Thomas et al., 2016; United States DHHS OIG, 2003; D. Williams et al., 1992). Hospital closures in total, to include rural hospital closures, have been associated with a disproportionate impact to older adults, minority populations, the poor, and/or those with public insurance (Friedman, 1990; Joynt, Chatterjee, Orav, & Jha, 2015; Kaufman, Thomas, et al., 2016; McLafferty, 1982; Reif et al., 1999; S. R. Thomas et al., 2015, 2016).

More recent reports describe closure characteristics related to the ACA: two-thirds of rural hospital closures in the period from 2010-2014 were located in Medicaid non-expansion states (Kaufman, Thomas, et al., 2016). Related, a large number of hospital closures have been in the Southeast U.S. where there is a greater concentration of for-profit hospitals that are likely to be in some sort of financial distress (Holmes et al., 2016; Joynt et al., 2015; Kaufman, Thomas, et al., 2016; Mullner & McNeil, 1986; S. R. Thomas et al., 2015; United States GAO, 2018).

Rural Hospital Closures: Causes

These characteristics of rural hospital closures often mirror the causes for their demise. A lack of economic vitality, as measured by decreases in revenue and occupancy as well as by increases in costs and uncompensated care, is a sign of rural hospital financial stress that may be caused by several factors. These factors include health care financing pressures and uncertainty, increasing market competition, and environmental changes such as the shift in the government's role to be more regulatory in nature (Ermann, 1990; S. D. Lee & Alexander, 1999).

Health care financing pressures on rural hospitals were first reported in the 1970s but became cause for concern in the 1980s with the implementation of the Medicare Prospective Payment System (PPS) (Gardiner et al., 1996; Mick & Morlock, 1990). Beginning October 1, 1983, hospitals were paid prospective Medicare payments for diagnosis related groups (DRGs), which resulted in differential revenues for rural hospitals (Mick & Morlock, 1990; Mullner et al., 1989). The financial pressure this created for rural hospitals was particularly harmful; the system was even described as having the opposite effect of the Hill-Burton Act (Cordes, 1989; Gardiner et al., 1996). In addition, overall poor reimbursement for Medicare and Medicaid services, especially in rural areas where these are high volume, continually contributed to this pressure (Gardiner et al., 1996; Premkumar et al., 2016). More recently, financing pressures related to non-expansion of Medicaid in certain states, Medicare sequestration cuts, and Medicare bad debt payments cuts have been reported to cause additional pressures leading to rural hospital closures (Lindrooth et al., 2018; United States GAO, 2018).

Changes in the Medicare payment methodology in the 1980s eventually led to increased competition in rural hospital markets, effectively removing hospitals that were operationally poor-performing (Mick & Morlock, 1990; Succi et al., 1997). A few authors have suggested that this is an appropriate response in a market-driven economy as the less efficient and lower quality businesses were removed (Joynt et al., 2015; D. Williams et al., 1992). One study assessing rural hospital closures between 1980 and 1987 found that hospitals that participated in a multi-hospital system were able to remain open, both as a result of financial stability and adaptation to the competitive market (Mullner et al., 1989). Diversification to meet community need has also shown to be protective against closure (Longo & Chase, 1984; Succi et al., 1997). Neither of these solutions are definite, however (Mick & Morlock, 1990). Research has suggested that competition is in fact less of a concern with more recent rural hospital closures [2010-2014] as these closures were farther away from their nearest hospital (Kaufman, Thomas, et al., 2016; S. R. Thomas et al., 2015).

Environmental pressures outside of the health care market have also been associated with rural hospital closures. The more isolated a rural hospital, and the further the hospital is from an urban area, the larger the local population must be to support the facility (Henderson & Taylor, 2003). In times of economic decline, such as that experienced in the U.S. during the 1980s and late 2000s, rural hospitals must work harder to overcome the financial stress described previously; it is well known that both of these time periods preceded significant numbers of rural hospital closures (Harmata & Bogue, 1997; Holmes et al., 2016; Moscovice, 1989; Mullner et al., 1989).

Other environmental factors that have been associated with hospital closure in rural areas include a low physician-to-population ratio, overall lack of physician availability, lack of adequate management, the shift from mostly inpatient to mostly outpatient care, the presence of a long-term care facility in the community, technological advances, hospital restructuring, and declining rural populations (Friedman, 1990; Longo & Chase, 1984; Moscovice, 1989; Mullner et al., 1989; Muus et al., 1995; Schull, Vermeulen, Slaughter, Morrison, & Daly, 2004; United States GAO, 2018). Together, these internal and external forces require hospitals to quickly adapt and strategically plan for their futures to avoid closure (Gifford & Mullner, 1988). Unfortunately, many rural hospitals, due in part to their thin financial margins and inability to access capital freely, have opted to be fiscally conservative, which has not allowed for funds to invest in planning new strategies (Mick & Morlock, 1990).

The actions of decision-makers in rural communities with regards to their investments in the health care system may be directly related to the actions of patients in choosing to bypass local hospitals for care elsewhere, creating further strain on rural hospital finances (Harmata & Bogue, 1997; Radcliff, Brasure, Moscovice, & Stensland, 2003). Patients' bypass behavior has been reported in the literature as occurring as much as 20-60% of the time (J. Liu, Bellamy, & McCormick, 2007; Radcliff et al., 2003). The reasons for bypass vary by diagnosis, patient payment source, perceptions of care available locally, age, gender, race/ethnicity, and income. In general, patients with more complex cases, those who are younger, men, minorities, and those who are more affluent tend to bypass their local rural hospital (J. Liu et al., 2007; Premkumar et al., 2016; Radcliff et al., 2003; Villapiano et al., 2017). However, when experiencing an urgent condition, patients may not bypass their local hospital, especially in times of economic downturn (Mick & Morlock, 1990; Radcliff et al., 2003).

Mick and Morlock describe closure as an "extreme outcome" of strategic decisions meant to respond to these stressors that put hospitals at risk (1990). Some hospitals at risk for closure are in fact able to remain open due in part to community support (Gifford & Mullner, 1988; Longo & Chase, 1984; Mayer et al., 1987). This is an important consideration for rural areas, due to the impact rural hospital closures have on the local economy and access to health care services (Moscovice, 1989; Reif et al., 1999; Rohrer, 1989; Succi et al., 1997).

Rural Hospital Closures: Impact

Economic

Rural hospitals not only experience the impact of the highs and low of their local economy, but they also have a tremendous economic influence on their communities, especially the loss felt in the event of a hospital closure (McKay & Coventry, 1993). The relationship between a rural hospital and its local economy is an interesting paradox; on one hand, a rural hospital needs a strong local economy to thrive and yet, if a rural hospital is at risk for closure and/or closes, there are significant impacts to the overall economic vitality of the community including declines in local employment and economic development opportunities (Longo & Chase, 1984; McKay & Coventry, 1993; D. Williams et al., 1992).

Thus, a rural hospital's economic viability is a critical issue for policymakers, especially if it is the only hospital and/or large health care provider in a county (Holmes, Slifkin, Randolph, & Poley, 2006; Moscovice, 1989). For rural counties that experienced a hospital closure in the 1980s, a $20.5 million loss (without inflation) was realized in aggregate due to a decline in the labor force and overall earned income locally (Probst, Samuels, Hussey, Berry, & Ricketts, 1999). One study using data for rural hospital closures in the 1990s reported a decrease in average per-capita income by $703 in communities where the only hospital closed (Holmes et al., 2006).

Related, the financial impact to individual patients as a result of a rural hospital closure has been described only briefly in the literature. Patients who must seek care in an urban teaching facility, spend more time in the hospital due to an increased distance from home, or delay care may experience higher costs for treatment (McKee, 2004; Shepard, 1983). These higher costs may be experienced simultaneously with tight household budgets as the rate of income growth is much slower in closure counties as compared to those areas that did not experience a closure (Holmes et al., 2006). Further, individual patient access to primary care may be diminished due to financial constraints of the community (Holmes et al., 2006).

Access to Ambulatory Services

Recruitment and retention of health care providers, especially physicians, is an existing challenge for rural communities which is often exacerbated when a rural hospital closes (Henderson & Taylor, 2003; Reif et al., 1999). These providers are a necessary component of a local health care delivery system, especially for providing access to ambulatory services such as primary care. If these services are not available locally, patients are forced to seek care outside of their own community, resulting in significant personal and economic barriers to access (P. E. McNamara, 1999; Meit et al., 2014; Moscovice, 1989). Increased distance and travel time to the next closest facility, a lack of continuity of care, longer wait times, more difficulty scheduling medical appointments, and misconceptions about available access may all lead to delays in care (Bindman et al., 1990; Reif et al., 1999). Rural communities experiencing closure may need to prioritize maintaining a basic level of health care services, as availability of these options may help reduce patient burden as well as influence physician decision-making when attempts are made to recruit and/or retain them in the community (Henderson & Taylor, 2003; P.E. McNamara, 1999).

Access to Hospital Services

Communities with a strong local economy may be able to preserve access to care by expanding hospital service areas, through regionalization of care, or by converting to another type of health care service (Goody, 1993; McKay & Coventry, 1993; S. R. Thomas et al., 2015). Rural hospitals at risk for closure may in fact have three different outcomes: closure, conversion, or specialization; distance to the next closest facility may dictate this outcome (Burkey, Bhadury, Eiselt, & Toyoglu, 2017; Harmata & Bogue, 1997; McKay & Coventry, 1993). Of the rural hospitals that closed during the period between 2013-2017, 53% were able to convert to some other facility type (United States GAO, 2018). These conversions to other types of facilities may make it difficult to determine the true impact of a rural hospital closure on access to care (L. Liu, Hader, Brossart, White, & Lewis, 2001; McKay & Coventry, 1995).

Inpatient care

There is no clear association in the literature between U.S. rural hospital closures and impacts on inpatient hospitalizations (P.E. McNamara, 1999). One study reported no change in inpatient admission rates or utilization of services (Joynt et al., 2015). Another study reported a decrease in hospital admissions among rural residents that experienced a hospital closure, with any admissions that did occur post-closure more likely to be at an urban teaching facility (Rosenbach & Dayhoff, 1995).

There are a variety of reasons why changes in hospital admission rates may or may not vary after a hospital closure. The overall health care delivery system may have been able to meet the rural residents' need for inpatient hospital beds in a nearby and/or urban facility. If indeed patients were already seeking care in an alternate hospital, no impact on hospital access would be seen; in fact, a full third of rural residents' hospitalizations in 2007 occurred in urban facilities (Fleming et al., 1995; Rohrer, 1989; Samuels, Cunningham, & Choi, 1991; Stranges, Holmquist, & Andrews, 2010). However, while this rationale may indicate at least some access to hospital services is maintained post-closure, there are segments of the population that, after their local rural hospital closes, wait until their disease has progressed much further to seek services (Rosenbach & Dayhoff, 1995). Several studies agree that access for populations vulnerable prior to a rural hospital closure (i.e. the elderly, the uninsured, the poor, those in need of emergency services, those without transportation, etc.) is more compromised after the closure occurs (Bindman et al., 1990; Fleming et al., 1995; McKay & Coventry, 1995; Mick & Morlock, 1990; Muus et al., 1995).

Maternity care

The effect of the loss of hospital-based services is extremely apparent in one such population of vulnerable residents: pregnant women. Only about half of rural hospitals even provide obstetric services, most of which are larger rural facilities (Freeman et al., 2015). Recent research has indicated that closure of rural hospital-based obstetric services has profound effects on pregnancy and childbirth outcomes. Rural pregnant women experiencing loss of obstetric services traveled farther to receive necessary care, which was associated with longer lengths of stay, higher costs, greater risk for complications, and overall higher stress for pregnant women (Hung, Kozhimannil, Casey, & Moscovice, 2016).

Another study found that the impact of hospital obstetric unit closures was that pregnant women residing in rural counties that experienced these closures had a higher number of out-of-hospital and pre-term births compared to those residing in counties that did not experience closures (Kozhimannil, Hung, Henning-Smith, Casey, & Prasad, 2018). Further, in another study, pregnant women with co-morbid chronic conditions such as asthma, diabetes, hypertension, and obesity demonstrated higher emergency department (ED) utilization (Cunningham et al., 2017). Rural hospital closures may further exacerbate these conditions if ED services become unavailable as a result.

Emergency Care

The basic tenet of the modern U.S. emergency health care system is that "rapid diagnosis and early intervention in acute illness or acutely decompensated chronic illness improves patient outcomes" (Neumar, 2007). The location of services provided through this system is primarily an emergency department (ED), the majority of which are associated with an acute care hospital (Sullivan et al., 2012). The nature of the care that is provided in EDs may influence patient outcomes not only in the short-term but also may in fact have downstream consequences for patient morbidity and mortality (Kocher, Haggins, Sabbatini, Sauser, & Sharp, 2014).

Emergency Department (ED) Characteristics

The U.S. Emergency Department (ED) is always open and provides care without appointment and regardless of a patient's payment source, making it one of the nation's most accessible health care providers, especially in rural areas (Institute of Medicine, 2007; Pines, Hollander, Localio, & Metlay, 2006; Sharp et al., 2014). This is possible due to the passage in 1986 of the Emergency Medical Treatment and Active Labor Act (EMTALA), which requires that hospitals providing emergency or trauma services must provide a medical screening exam for all patients presenting to the facility in need of such services (Institute of Medicine, 2007). EDs specialize in providing immediate health care for patients suffering from an urgent need, such as trauma; however, they often also provide primary care services for the safety net population (Institute of Medicine, 2007). Differences in size, ownership, and location of EDs mean that staffing, resources, costs, and access (and therefore experience of care) vary widely (Baehr, Martinez, & Carr, 2017; Glickman et al., 2010; Institute of Medicine, 2007; Pines et al., 2006).

There were approximately 136.9 million ED visits in the U.S. in 2015, of which 24.8 million occurred in micropolitan or noncore/nonmetro areas (Centers for Disease Control and Prevention, 2015). Overall ED visit rates have increased between a third and a half between 1996 and 2009, resulting in increasing hospital admissions from the ED by 50%; overall hospital admissions only increased by 15% during the same time period (Abualenain et al., 2013; C. Liu, Srebotnjak, & Hsia, 2014; Morganti et al., 2013; Schuur & Venkatesh, 2012). Elderly Americans are often high utilizers of the ED, especially for cardiovascular or respiratory events, and comprise a large majority of ED admissions to inpatient care (Caines, Shoff, Bott, & Pines, 2016; Chen, Cheng, Bennett, & Hibbert, 2015; Gruneir, Silver, & Rochon, 2011; J. Lee et al., 2007; McCusker, Karp, Cardin, Durand, & Morin, 2003). Increased ED utilization may be associated with daily overcrowding of these facilities, which results in delays in care, increased lengths of stay and wait times, higher numbers of patients leaving without treatment, care rationing in order to meet multiple patient needs at once, increased transport times, and even mortality (Bernstein et al., 2009; Chen et al., 2015; Hsia, Kellermann, & Shen, 2011; A. J. Singer, Thode, Viccellio, & Pines, 2011; Sun et al., 2013, 2006).

While EDs located in rural communities have these same general characteristics, their typically lower volumes create specific challenges of having adequate staff on hand to appropriately treat conditions in which the timing is difficult to predict (Institute of Medicine, 2007; J. M. Williams, Ehrlich, & Prescott, 2001). As they may be located greater distances from their patients' homes and may also often see patients in need of higher levels of care, rural EDs must specialize in quick assessments, stabilization, and transfer (J. Lee et al., 2007; J. M. Williams et al., 2001). Despite the noted challenges, rural EDs are often seeing increased demand for care associated with patients' increasing age, acuity of illness, limited access to primary care, minority status, and/or payment source (J. Lee et al., 2007; Ragin et al., 2005). The loss of rural EDs as a result of rural hospital closures will further exacerbate these challenges and may contribute to issues of access as well as increased patient morbidity and mortality.

Emergency Department (ED) Closures

ED closures are occurring across the U.S. and are associated with for-profit ownership, a lack of profitability, location in high poverty areas, and being located in a competitive market (Capps, Dranove, & Lindrooth, 2010; Carr et al., 2009; Hsia, Kanzaria, et al., 2012; Hsia et al., 2011; Lindrooth et al., 2018; C. Liu et al., 2014; McKay & Coventry, 1995; Sun et al., 2006). ED closures, similar to rural hospital closures, are in underserved, minority, and/or low-income areas, especially those with high Medicaid and uninsured populations, and result in destabilization of the safety net by limiting access to local health care options (Bernstein et al., 2009; Chen et al., 2015; Hsia, Kanzaria, et al., 2012; Hsia, Srebotnjak, Kanzaria, McCulloch, & Auerbach, 2012; C. Liu et al., 2014; Trzeciak & Rivers, 2003).

ED closures have been associated with increased travel and wait times, ED overcrowding, delays in seeking care, diversion of ambulance traffic, and overextended staff, which may result in delays in treatment and even mortality (C. Liu et al., 2014; Trzeciak & Rivers, 2003). ED closures occurring in California in the 2000s were associated with increased overall odds of in-hospital mortality of 5% as well as higher odds of in-hospital mortality from AMI, sepsis, and stroke (C. Liu et al., 2014). Another study found that nationally an increase in 30 minutes driving time to the next closest ED after a closure resulted in transient increases in long-term mortality (Shen & Hsia, 2012).

Emergency Medical Transportation

In addition to emergency care provided inside an ED, emergency medical services (EMS) provide transportation to and between EDs and other facilities while facilitating timely and appropriate levels of intervention (Saha, 2006; Young et al., 2003). Depending on the perceived severity of their initial symptoms, patients may seek to utilize EMS by dialing 9-1-1. EMS response may be fulfilled by an organized network of paid Emergency Medical Technicians that operate as a government-based stand-alone EMS service or are affiliated with a hospital or a fire department. However, in rural areas, there may also be an extensive network of volunteer first responders that respond to emergency calls (Patterson, 2015). Rural patients may also choose to find another form of transportation to an ED. One study of major trauma events in Iowa reported ambulance use to be higher among patients involved in motor-vehicle accidents, the elderly, women, and those with limited transportation options, while patients with injuries sustained on a farm were more likely to self-transport (Young et al., 2003).

Patient outcomes may be associated directly or indirectly with EMS utilization. For patients experiencing AMI that were transported to the ED via ambulance, initial therapies have been reported to occur more quickly (Canto et al., 2002). However, EMS utilization may also result in diversion of ambulances to facilities other than the closest for care, as was reported in Los Angeles County, California due to hospital closures (Sun et al., 2006). Diversion has been associated with increased mortality odds among patients experiencing AMI and trauma (Begley, Chang, Wood, & Weltge, 2004; Shen, 2011). Finally, a study comparing ambulance transport times before and after rural hospital closures showed rural patient transport times increased 76% in the year after a hospital closure occurred as compared to the year prior to closure (Troske & Davis, 2019).

Regionalization

Due to the ultimate consequences of services provided in the emergency care system resulting in potential increases in patient morbidity and mortality, multiple groups have called for the regionalization of time-sensitive care for illnesses that require immediate intervention for optimal outcomes. Regionalization of services would allow for clinical collaborations that support the provision of high-quality care at all points along the emergency care continuum (Carr, Conway, Meisel, Steiner, & Clancy, 2010; Kindermann, Mutter, Houchens, Barrett, & Pines, 2015; Nugent, 2000). In particular, access to hospital resources such as specialized inpatient care may be necessary to ensure good outcomes for patients with these conditions, which often requires facilities work together (Carr et al., 2010).

Regional networks include connections between receiving and referral hospital facilities, cooperation among EMS providers, and standardized protocols to ensure care is provided in the right place at the right time, resulting in improved patient outcomes (Delgado et al., 2014; Edwards & Carr, 2010; Glickman et al., 2010). Patients treated in regional systems, where they exist, are more likely to be the very young, the elderly, those most acutely ill, and those with Medicare, Medicaid, or who are uninsured (Kindermann et al., 2015). It is unknown how regional systems may be created, altered, and/or dissolved in the aftermath of a rural hospital closure.

<u>Post-Closure Relationships between Hospital Services and Quality of Care</u>

Finally, while hospital closures are not a desired outcome for maintaining access to health care in rural areas, there may be tradeoffs in quality or efficiency of care if certain facilities remain open (Lindrooth et al., 2018). For example, there is some indication that closing a rural hospital with unknown or poor quality of care may actually increase patients' access to regional health systems that, through sheer volume of procedures completed, have demonstrated increased efficiencies and overall better outcomes (Capps, et al., 2010; Fleming et al., 1995; Hsia, Kanzaria, et al., 2012; Joynt et al., 2015; Mayer et al., 1987; McLafferty, 1982; Moscovice, 1989). On the other hand, a study of Iowa rural hospitals suggested that preferentially closing a quarter of the lowest quality hospitals would result in overall increased distance to care of 20%; however, if the least used were closed, quality would actually decrease (Premkumar et al., 2016). Relationships between volume of care provided and associated outcomes are not well understood in the context of rural patients that experience hospital closure in their community. More work is needed to elucidate these associations.

Health Outcomes

Likewise, associations between rural hospital closures and health outcomes found in the literature are ambiguous at best (Mick & Morlock, 1990). To start, rural populations already experience worse health outcomes compared to their urban counterparts without considering potential impacts of closures. For example, rural populations experience excess in-hospital mortality compared to urban populations, even when controlling for age and payment source. This disparity has sharply increased since 2008 as a result of higher disease incidence and prevalence, decreased access to services, and contributing socio-economic and environmental factors, such as unemployment, among rural populations (Villapiano et al., 2017).

The primary health outcome of concern for all populations is mortality, which is a common, specific, time-bound, and measurable event. Specific studies describing the relationships between U.S. rural hospital closures and mortality are outlined in Table 2.1. Half of these studies found no association between rural hospital closures and mortality, while the other half found a weak association. One study of Canadian rural hospital closures (not listed) reported improvements in mortality rates (L. Liu et al., 2001). Non-rural hospital closures have been associated with declines in overall health status and increased mortality from heart attacks and unintentional injuries, especially among the elderly (Buchmueller et al., 2006).

These studies assessing mortality among residents who experienced rural hospital closures have only minimally described the impact of these closures among emergency and trauma patients, where added travel time – even 30 minutes – can have an impact on outcomes (Fleming et al., 1995). Despite sometimes seeking inpatient hospital services in other locations, the local ED is a critical health care access point in the minds of many rural Americans. This is due to their real or perceived isolation combined with the potential for major clinical events or traumatic injuries (Fleming et al., 1995; McKay & Coventry, 1995; Reif et al., 1999). Since one of the primary functions of a rural hospital is to provide ED services, the implications of rural hospital closures on the health outcomes of patients seeking emergency care is a specific gap in the literature (Arcury et al., 2004; Moscovice, 1989; Schull et al., 2004).

Table 2.1 Findings from studies of U.S. rural hospital closures' association with mortality

First Author, Year	**Characteristics of Rural Hospital(s)**	**Study Sample Characteristics**	**Time Period**	**Outcome**
Bindman, 1990	73-bed public, acute care facility located in semi-rural area of northern California	Inpatients from closure hospital were followed post-closure to assess outcomes	1986-1988	Loss of access contributing to decline in self-reported health; more deaths in study period compared to another similar population
Hsia, 2012	Rural and urban non-federal hospitals with ED closure in California	Patient admissions for time-sensitive conditions from administrative data	1999-2009	Odds of in-hospital mortality among time-sensitive conditions were not higher among patients with increased distance to the nearest ED
Joynt, 2015	Rural and urban hospital closures	Medicare fee-for-service beneficiaries' administrative data at the hospital service area (HSA) level	2003-2011	Rural HSAs were found to have no significant differences in population-level mortality comparing closure to non-closure areas

C. Liu, 2014	Rural and urban non-federal hospitals with ED closure in California	Patient admissions from administrative data	1999-2010	Admissions impacted by ED closure resulted in 5% higher odds of in-hospital mortality; this finding persisted for heart attacks (15% higher odds), stroke (10%), and sepsis (8%)
Rosenbach, 1995	Eleven rural hospitals in six states experiencing closure in 1986 or 1987	Medicare beneficiaries' administrative data	1985-1989	Rates of mortality per 1,000 Medicare beneficiaries increased after two years post-closure in affected areas but the results were not significant
Shen, 2012	Rural and urban hospitals experiencing ED closure	MedPAR administrative data from patients experiencing acute myocardial infarctions (AMIs)	1996-2005	AMI patients experiencing greater than 30 minutes' increase in time to ED had an increase in 1-year mortality rates

Emergency Care Sensitive Conditions (ECSCs)

Time-sensitive illnesses, that is, illnesses where the rapidity of care provided is an important contributing factor to the overall outcome, are particularly sensitive to the services provided in the emergency care system (Kocher et al., 2014). Timely treatment of these illnesses in the ED has been shown to result in decreased morbidity and mortality overall (Bernstein et al., 2009; Dresden, 2013; Kocher, Dimick, & Nallamothu, 2013; Sharp et al., 2014). In addition, timely treatment of these conditions provides high value for patients and their insurance companies: patients are able to feel better and resume normal activities quicker, and insurance companies secure services that are not available in other settings (Sharp et al., 2014).

Recent discussions of time-sensitive illnesses have given way to a more formal definition of these conditions in order to assess common treatment pathways, measure outcomes of care, and improve interventions: emergency care sensitive conditions (ECSCs) (Carr et al., 2010). Carr and colleagues coined this terminology in 2010, defining ECSCs as "conditions for which rapid diagnosis and early intervention in acute illness or acutely decompensated chronic illness improve patient outcomes". Examples of such illnesses include trauma, pediatric trauma, acute myocardial infarctions, ST-elevation myocardial infarctions (STEMIs), acute ischemic stroke, sepsis, cardiac arrest, congestive heart failure, burn care, and neonatal care (Baehr et al., 2017; Carr et al., 2010; Myers et al., 2013; Sharp et al., 2014). Clinicians refer to time-to-treatment as the "golden hour" (60 minutes to intervention) or "golden half hour" (30 minutes to intervention) as indicators of approximate survivability associated with treatment for these conditions (Burkey et al., 2017; Saver et al., 2010).

Universal access to timely care is a critical component for treating ECSCs (Carr et al., 2009). A national study of the ability for U.S. residents to access emergency care within 60 minutes included most populations; however, using 30 minutes as the indicator, only about half of rural populations were able to access emergency treatment in that period of time (Carr et al., 2009). A study of four Southeast U.S. states found that 91-94% of their populations were within 30 minutes of a hospital regardless of their location (rural or urban) (Burkey, Bhadury, & Eiselt, 2012). Another study that only included two states showed that nine percent of the population of the states combined was unable to reach any ED within one hour and 25% of the study population had no access to an advanced or comprehensive ED in that amount of time (Myers et al., 2013).

Studies of patients experiencing ECSCs that were subject to lack of timely access to EDs varied with respect to mortality outcomes, which may be associated with the quality of care received at the treating facility (Hsia, Kanzaria, et al., 2012; Kocher et al., 2013; Myers et al., 2013). Research regarding the association of ED overcrowding with outcomes for time-sensitive illnesses also demonstrated mixed results (Bernstein et al., 2009; Pines et al., 2009, 2006; Schull et al., 2004; Sun et al., 2006). It is unclear how rural hospital closures may affect timeliness of care for these conditions. The most common ECSCs and the most dependent on efficient and timely access to definitive care for rural residents are acute myocardial infarction, acute ischemic stroke, sepsis, and trauma. Below the current incidence, clinical significance, and known systems of care in rural areas of the U.S. are described further.

Acute Myocardial Infarction (AMI)

Acute myocardial infarctions (AMIs), also commonly known as heart attacks, are a leading cause of death among U.S. populations (Veinot, Bosk, Unnikrishnan, & Iwashyna, 2012). Outcomes may be sensitive to certain patient characteristics: African Americans may have worse outcomes or missed diagnoses; insurance type may be associated with poor outcomes; and younger people are likely to be misdiagnosed (Moy, Barrett, Coffey, Hines, & Newman-Toker, 2015; Saha, 2006). There is some evidence to indicate a disparity between rural and urban residents experiencing AMI with at least one study reporting higher 30-day mortality rates for AMI patients treated at rural hospitals compared to urban (Baldwin et al., 2004; Sheikh & Bullock, 2001).

The treatment for AMI is thrombolytic therapy given up to 12 hours after symptom onset; however, improved outcomes are realized if the treatment is given within one to two hours (Boersma, Maas, Deckers, & Simoons, 1996; Newby et al., 1996). For patients experiencing a specific type of AMI known as a ST-elevated myocardial infarction, referred to as a STEMI, the preferred intervention is revascularization through a procedure called primary percutaneous coronary intervention (PCI) (Nallamothu, Bradley, & Krumholz, 2007; Veinot et al., 2012). Receiving PCI treatment within 90 minutes of symptom onset is the standard of care and has demonstrated significantly improved patient outcomes, including decreased in-hospital mortality (Cannon et al., 2000; R. L. McNamara et al., 2006; Veinot et al., 2012).

Approximately 50% of patients admitted to community hospitals with AMI are transferred to other facilities based on protocols, resulting in better care outcomes (Bosk, Veinot, & Iwashyna, 2011; Veinot et al., 2012). Patients not transferred may be more likely suffering from extensive co-morbidities (Mehta, Stalhandske, McCargar, Ruane, & Eagle, 1999). PCI centers for treatment of STEMIs are available in some regions but are largely reactive and not yet optimized to provide care to all residents. Facilities with higher STEMI patient volumes have demonstrated improved outcomes over other lower volume facilities (Edwards & Carr, 2010). Development of true regional systems of care for STEMI patients needing immediate transfer to a PCI capable facility is a feasible, though not fully realized, component of the rural health care delivery system (Henry et al., 2007; Nallamothu et al., 2007).

Acute Ischemic Stroke

Stroke is one of the leading causes of death and disability among U.S. populations each year and acute ischemic stroke accounts for 80% of all cases (Kumar, Khera, Pandey, & Garg, 2016). It is known that the risk of having a stroke is higher among minorities, low-income populations, and rural residents (Mullen et al., 2013). In particular, residents of the Southeastern U.S. live in an area with so much excess morbidity and mortality from stroke that it is called the "stroke belt" (Mullen et al., 2013). A recent study of racial differences in patient outcomes found that while minority stroke patients, especially African Americans, were less likely to receive thrombolytic therapy and have longer lengths of stay and higher costs for care, they were less likely to die in the hospital (Kumar et al., 2016).

There are two main treatment options for acute ischemic stroke. One, mechanical thrombectomy, has been found to improve outcomes for stroke patients if initiated within seven hours (Saver et al., 2016). The second, and more popular intervention, is the use of intravenous tissue plasminogen activator (tPA). This treatment must be given within three to four and a half hours after symptom onset for maximal efficacy; evidence supports the earlier the better for decreased mortality and other positive patient outcomes (Marler et al., 2000; Saver et al., 2013, 2010; Wardlaw et al., 2014). In spite of this evidence of treatment efficacy, less than eight percent of stroke patients receive this therapy (Fassbender et al., 2013). A large percentage of those not receiving treatment are due to patient delays in seeking care; lack of awareness of symptomology among patients as well as EMS providers; and in-hospital delays such as provider availability and waiting for imaging results (Evenson, Foraker, Morris, & Rosamond, 2009; Fassbender et al., 2013).

Internal hospital systems development, such as utilization of stroke teams, can increase tPA use and support downward trends in mortality (Albright et al., 2010). External systems of organized stroke care such as accredited Primary Stroke Centers (PSCs) reduce mortality; yet, many of the areas afflicted with high stroke rates, such as the "stroke belt", are less likely to have access to the level of treatment needed nearby (Edwards & Carr, 2010; Mullen et al., 2013). One study reported that only about 1 in 5 U.S. residents has access to a PSC within 30 minutes and just over half have access within 60 minutes (Albright et al., 2010). Clinical teams have begun to explore additional care options for stroke patients, including the use of telemedicine and other mobile technologies to treat patients as well as incorporating air ambulance flights into treatment arrangements (Albright et al., 2010; Fassbender et al., 2013).

Sepsis

Sepsis, as most recently defined by a task force organized by the Society of Critical Care Medicine and the European Society of Intensive Care Medicine, "is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection" (M. Singer et al., 2016). The ED is a primary entry location for care or patients with sepsis; overall in-hospital mortality for sepsis patients has been reported to range from as low as 18% to as high as 33% (Gaieski et al., 2014; Ofoma, Dahdah, Kethireddy, Maeng, & Walkey, 2017; Powell, Khare, Courtney, & Feinglass, 2012). While the incidence of sepsis is on the rise and is more likely to occur among the elderly, in-hospital mortality related to sepsis is declining (Dombrovskiy, Martin, Sunderram, & Paz, 2007; Jones et al., 2017; Rivers et al., 2001; M. Singer et al., 2016). There may be associations between patients who are low-income or minority and an increased risk of mortality from sepsis (Jones et al., 2017; Rush et al., 2017).

Given the implications of organ failure and complications from septic shock, timeliness of the chosen intervention is key (M. Singer et al., 2016). Administration of antibiotics within six hours is an important intervention; the earlier these antibiotics are given in that six-hour window, the odds of in-hospital mortality decrease (V. X. Liu et al., 2017). Goal directed therapy has demonstrated improvements in mortality if administered early in the treatment (Carr et al., 2009; Rivers et al., 2001). A study of New York hospitals utilizing 3-hour bundle protocols (i.e. blood culture, antibiotic administration, and intravenous fluids given) demonstrated decreases in mortality with more timely completion of the bundle and antibiotic administration (Seymour et al., 2017).

In national studies, EDs treating a higher volume of sepsis patients have been associated with decreases in in-hospital mortality; ED admission versus direct admission also has improved patient outcomes (Gaieski et al., 2014; Ofoma et al., 2017; Powell, Khare, Courtney, & Feinglass, 2010; Powell et al., 2012). A study of rural Iowa hospitals found that increased mortality from sepsis was associated with bypassing the local rural hospital (Mohr et al., 2017). In-hospital mortality from sepsis has been reported to be higher in urban versus rural patients (Villapiano et al., 2017).

Trauma

Injury is a leading cause of death among children, youth, and adults up through middle age. In fact, 35% of all ED visits are related to a traumatic injury (Institute of Medicine, 2007). Using national survey data, recent research indicated a 14% greater risk of mortality from trauma for patients residing in rural areas (Jarman, Castillo, Carlini, Kodadek, & Haider, 2016). This geographic disparity is reinforced when considering that trauma from motor vehicle crashes results in mortality that is twice the rate in rural areas versus urban (Gonzalez, Cummings, Phelan, Mulekar, & Rodning, 2009). Other populations at high risk for mortality from trauma include the elderly and low-income persons (Jarman, Curriero, Haut, Porter, & Castillo, 2018).

The American College of Surgeons is a proponent of the "golden hour" in trauma care which supports the principle that patients that receive early assessment and triage have improved outcomes (Tien et al., 2011). This persists as the standard of trauma care in spite of mixed evidence that both supports and refutes this assertion (Lerner & Moscati, 2001; Newgard et al., 2010; Rogers, Rittenhouse, & Gross, 2015; Tien et al., 2011). However, due to a lack of trauma system resources in rural areas, the "golden hour" is still an important indicator of access to care. Results from a study conducted in the state of Washington concluded that trauma calls in rural areas were subject to longer response and transport times, longer scene times, and a seven times higher risk of mortality before arrival to the hospital if the transport was longer than 30 minutes (Grossman et al., 1997). A similar study in Alabama of fatal motor vehicle crashes associated increased EMS times with higher mortality (Gonzalez et al., 2009).

The U.S. trauma system is the most established regional system of health care focused on the specialized treatment of trauma patients (Carr et al., 2009; Delgado et al., 2014). These systems were first established in the 1980s and have been shown to be effective at directing rural patients to care, reducing mortality, and improving quality of life post-injury (Delgado et al., 2014; Hsia, Wang, Torres, Saynina, & Wise, 2010; MacKenzie et al., 2006). However, there are still gaps in the system with regards to full coverage of the population, especially when considering distance to higher level trauma centers (Branas et al., 2005; Hsia et al., 2010; Institute of Medicine, 2007; Jarman et al., 2016). Approximately 28% of the U.S. population was reported to only have access to a Level 1 or 2 Trauma Center within an hour even if transported by helicopter (Branas et al., 2005). Further causes of persistent rural disparities may include the public's general lack of knowledge of how the system works, distances that EMS must travel, the capabilities of local EMS, and types of injuries sustained (Delgado et al., 2014; Young et al., 2003).

Theoretical Model for Research

Mortality, the primary outcome for this study, is a definitive marker of quality of health care. Using the model forwarded by Donabedian to study quality of care, this study will focus on the structure, process, and outcome of care for rural populations seeking treatment associated with an ECSC. According to the model, full comprehension of these three domains is necessary to determine quality (Donabedian, 1988). Structure defines the areas in which care processes occur and may include resources, organizational structures, and similar features of the health care delivery system. Process describes the ways in which care was rendered by the provider as well as how it was sought and received by the patient. Outcome delineates how the care impacts the health of the population. It is necessary to understand the linkages between the structure and process as well as the process and outcome to fully evaluate the quality of care provided (Donabedian, 1988).

An illustration of the Donabedian model applied to this study is provided as Figure 2.1. Conceptually, this model has two options: that of a rural hospital pre-closure and a rural hospital post-closure scenario. In the pre-closure scenario, which will also apply to comparison areas with existing rural hospitals that remain open, as described further in the methodology section, rural patients may choose to seek care either at the ED of the closest rural facility or otherwise seek care in an alternate ED. In the post-closure scenario, which will also apply to comparison areas without a hospital as described further in the methodology section, the only available option for rural patients is to seek care in an alternate ED. In both scenarios, no distinction is made as to whether the patient arrives by ambulance or through self-transport. Based on the literature review, the status of Medicaid expansion in the state may be associated with the rural hospital closure.

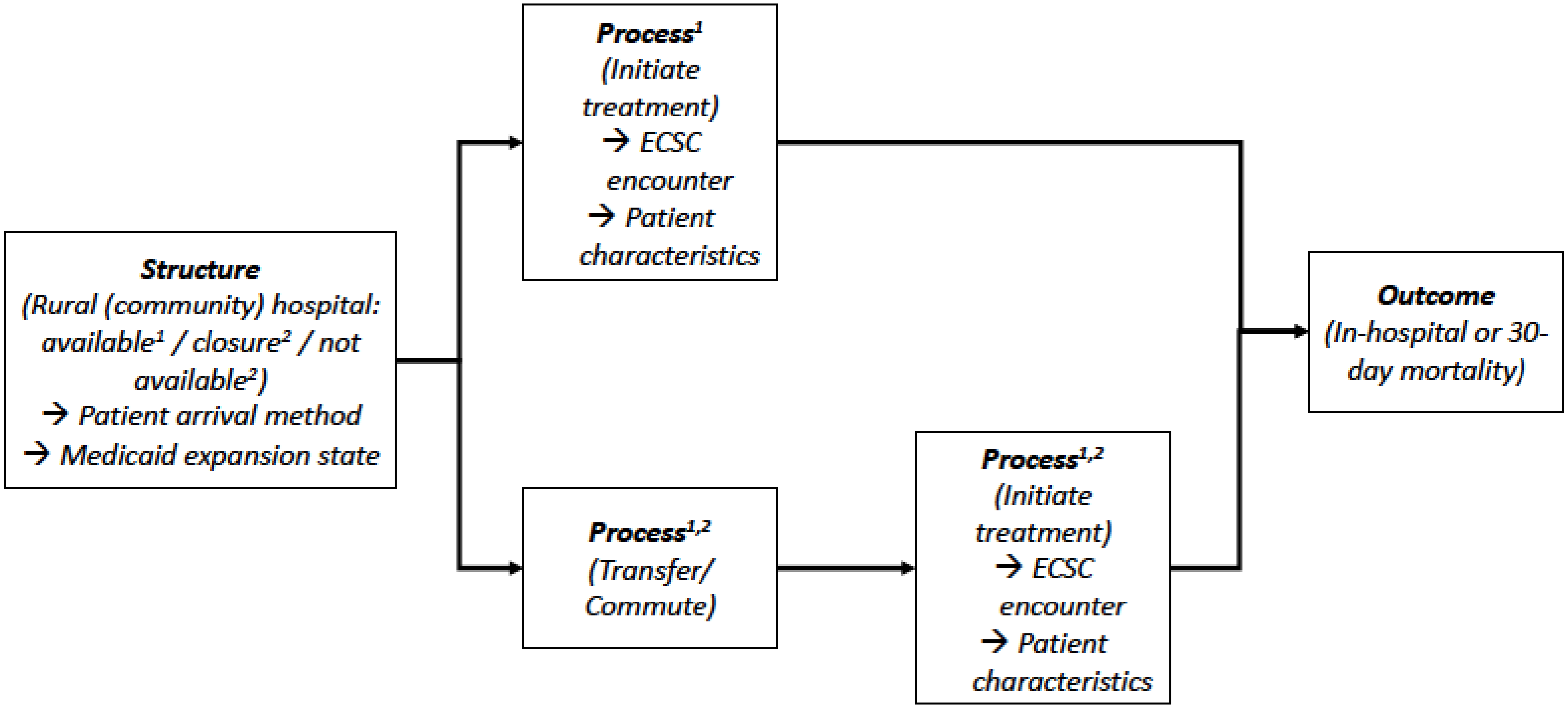

Figure 2.1 Theoretical framework

The hospital where the patient seeks care, either rural or alternate, defines the element of structure in the Donabedian model. The process of obtaining care is different based on which hospital health care services are initiated in, both from the perspective of where that care is located as well as from the perspective of patients seeking care. The location of health care services in this model is either at the rural or alternate hospital. The rural hospital is an option for patients who have a local hospital, either before closure or for those not affected by closure. However, even if the rural hospital is chosen, two care pathways are present. In one, the patient is assessed, and treatment occurs in that facility. In the second, the patient is assessed, and the decision is made to transfer the patient to an alternate hospital where treatment occurs. The alternate hospital is therefore a potential option for all patients for assessment and treatment, though more heavily relied upon after closure or for those without a local hospital.

Further, although not shown in Figure 2.1, elements of Andersen's Behavioral Model of Health Services Use specifically affect this process step. According to Andersen, there are three characteristics which influence the use of health services and ultimately health outcomes among patient populations: predisposing characteristics, enabling resources, and need (Andersen, 1995). Predisposing characteristics include demographic and social factors that set the context for the likelihood of perceived need for health care services. Enabling resources are at the community and personal levels: are there health care services available and does an individual have the capacity to access them? Need is defined as both perceived and actual evaluated need for services.

Thus, for rural communities that experience hospital closure, the process of care is both heavily influenced by the structure of what is available and where after closure, by enabling resources as described above, and also by changes for populations whose socio-economic scenario and/or perceived need for care shift after closure. For example, a diminished ability to pay for care as a result of job loss and/or costs associated with additional transportation required to seek care may preclude or delay access to care for affected populations. Symptoms of serious illness may be dismissed or overlooked as a result of the distance to a hospital post-closure, diminishing the perceived need for care. These changes in health seeking behavior as a direct result of rural hospital closure affect when patients may initiate assessment of and treatment for their illnesses.

Ultimately, where and when patients seek health care services after closure impacts the total time it takes until the patient receives definitive treatment, which is a critical predictor of mortality among those experiencing ECSCs. Thus, this is the outcome of interest for this study. Specifically, in-hospital mortality associated with ECSCs for research questions 1 and 2 and 30-day post hospital discharge mortality associated with ECSC discharges for research question 3 were assessed using this framework to test the assumption that time is a critical factor in the care pathway that is significantly impacted as a result of rural hospital closure.

CHAPTER 3

METHODOLOGY

Purpose

This study sought to identify associations between rural hospital closures and health outcomes, specifically mortality. Since effects on overall population mortality may not be realized for many years after a rural hospital closure, in-hospital and 30-day post hospital discharge mortality associated with emergency care sensitive conditions (ECSCs) were used as timelier representations of the potential impact. This is a highly relevant issue for rural populations that experience hospital closure as access to emergency services is often a primary concern (Fleming et al., 1995; McKay & Coventry, 1995; Reif et al., 1999). Here, patient hospital encounters for an ECSC were analyzed by rural hospital operational status to identify differences in in-hospital mortality. Further, data available in one of the study states linked mortality within 30-days post hospital discharge to patient hospital encounters to determine differences by rural hospital operational status.

Research Questions & Hypotheses

The study included three research questions:

Research Question 1: Examining all ECSC encounters as a group, is there a difference in in-hospital mortality during ECSC encounters for residents living in rural counties that experienced a hospital closure compared to residents living in rural counties that did not experience a hospital closure?

Hypothesis 1: Residents living in rural counties that experienced a hospital closure will have higher in-hospital mortality during ECSC encounters than residents living in rural counties that did not experience a closure.

Research Question 2: Does a difference in in-hospital mortality associated with rural hospital closure vary among specific ECSC diagnoses?

Hypothesis 2: In-hospital mortality during ECSC encounters associated with rural hospital closure will vary among specific ECSC diagnoses.

Research Question 3: Is there an overall difference in 30-day post hospital discharge mortality associated with ECSC encounters for residents living in a rural county that experienced a hospital closure compared to residents living in rural counties that did not experience a hospital closure?

Hypothesis 3: Residents living in a rural county that experienced a hospital closure will have higher 30-day post hospital discharge mortality associated with ECSC encounters than residents living in rural counties that did not experience a hospital closure.

Population Studied

Two U.S. states with rural hospital closures in the past decade were targeted to identify ECSC patient encounters for a period beginning two years prior to the closures up to two years after closures, for a total study period of five years. Secondary data was obtained from hospital discharges to identify the encounters. ECSCs were identified as discharges that were associated with acute myocardial infarctions (to include ST-elevation myocardial infarctions or STEMIs), sepsis, acute ischemic stroke, or trauma.

Comparison groups identified within the same states were utilized to help isolate the effects of the closures in the study model.

Definition of Study Groups

For the purposes of this study, the definition of a rural hospital as described by the Cecil G. Sheps Center for Health Services Research at The University of North Carolina at Chapel Hill was used to identify "short-term, general acute, non-federal hospital(s) that [are] a. not located in a metropolitan county OR b. located in a RUCA type 4 or higher OR c. a Critical Access Hospital" (Sheps Center, 2018). Data from the Sheps Center was used to identify the rural hospital closures in the study sample. Only hospitals that were reported to be permanently closed in these data were considered for study inclusion.

To identify comparison areas to these closures, a geographic service area proxy for rural hospitals was chosen. Rural hospital service areas defined by county and ZIP code boundaries have been identified in the literature based on market share (Kaufman, Thomas, et al., 2016; Succi et al., 1997; D. Williams et al., 1992). Since these financial data were unavailable for this study, and because comparisons to areas without hospitals were used, county boundaries were chosen as the proxy. Thus, the population subject to rural hospital closure was defined as residents of counties in which a rural hospital was reported as closed during the study period and for which data is available for two years before and two years after the closure year in each of the study states.

To differentiate the effects of the rural hospital closures from ongoing trends in patient mortality, four comparison counties in each state were chosen. Data from the 2010 U.S. Census was used to match comparison counties to closure counties because this demographic information was collected prior to the closures occurring. Four county-level characteristics were used to match these counties in both states: population density, median household income, percent minority population, and percent elderly population (Ly et al., 2011; Rosenbach & Dayhoff, 1995). Dendrograms were created after median linkage clustering analysis was used to identify matches (Rosenbach & Dayhoff, 1995). Any matches that were adjacent to closure counties or located along a state's border were excluded and the next closest match chosen. In the case of multiple matches, counties with the closest population densities were used (Rosenbach & Dayhoff, 1995).

Matching counties were then further described by the operational status of their local hospital using state licensure data and/or confirmed through communication with the State Office of Rural Health in each state. Two counties where the rural hospital remains open and two counties where there is no rural hospital (or at least where one has not been operating for the past thirty years) were chosen in each state for comparison (Rosenbach & Dayhoff, 1995). Since the 1980s included a large number of rural hospital closures, thirty years was chosen as a realistic cut-off point to ensure enough counties were available for matching.

After matching, ten counties in total, five from each study state, comprised the study groups from which to derive the study sample. (For research question 3, only the five counties from the state with linked 30-day post hospital discharge mortality data were used.) Finally, one-way analysis of variance (ANOVA) tests confirmed that there were no significant differences in the matching characteristics between the study counties. These county-level characteristics are provided in Tables 3.1 (both states) and 3.2 (second study state only).

Table 3.1 Demographic characteristics of study counties and other counties in both studied states, U.S. Census 2010

	Comparison Counties – Open Hospital (n = 4)	**Comparison Counties – No Hospital (n = 4)**	**Closure Counties (n = 2)**	**Other counties in states (n = 156)**
Population density (per square mile)	47.18	38.75	39.5	123.8
65yrs+ Population (%)	17.1	16.4	15.8	14.4
Minority Population (%)	25.2	23.8	33.7	16.6
Median household income ($)	34,600	37,786	36,399	37,564

Table 3.2 Demographic characteristics of study counties in second studied state only, U.S. Census 2010

	Comparison Counties – Open Hospital	**Comparison Counties – No Hospital**	**Closure County**	**Other counties in state**
Population density (per square mile)	55.8	41.2	42.4	132.4
65yrs+ Population (%)	16.7	16.2	16.0	14.4
Minority Population (%)	43.9	44.4	64.4	42.0
Median household income ($)	33,268	38,649	32,538	38,933

Data Sources

Three primary data sources were utilized for this study. Encounter data for one of the study states was obtained from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP). The State Inpatient Database (SID) and the State Emergency Department Database (SEDD) are two HCUP products that allow researchers to access state-level discharge summary data for all patients, irrespective of their payment type (Agency for Healthcare Research and Quality, n.d.). The SID and SEDD together include all patient encounters to hospitals and hospital-affiliated emergency departments (EDs) in the state on an annual basis. Data for calendar years 2012-2016 were obtained for analysis from the HCUP Online Central Distributor.

Encounter data for the second study state was obtained from that state's all-payer claims database system, which is required by state statute to collect and maintain uniform billing data from acute care facilities. While this state also participates in the HCUP, the level of access to the same encounter data used in the HCUP through the all-payer claims database enabled the ability to request encounters be linked using unique patient identification to available mortality data from the state's Vital Records department in order to address the third research question (which only uses data from this state). Data for calendar years 2010-2014 were obtained for analysis.

Study Definitions

Sample Inclusion Criteria

The study sample was comprised of patient encounters using the following inclusion criteria:

- Patient's county of residence is in one of the ten study counties (or one of the five for the second study state), identified using the variable patient state/county FIPS code ("PSTCO").
- Patient encounter occurs in a community hospital, identified using the variable community hospital that is not a rehabilitation or long-term acute care hospital ("COMMUNITY_NONREHAB_NONLTAC"). This variable is not available in the 2012 SID and SEDD datasets, so the 2013 data were used to interpolate 2012 values using the variable's data source hospital identifier ("DSHOSPID") plus the community hospital variable. Hospitals were assumed to have the same status for both years. Data from the second study state were provided as only including encounters from community hospitals.
- Patient encounter is for one of four emergency care sensitive condition diagnoses, as outlined below.

Sample Exclusion Criteria

Criteria for exclusion from the study sample included the following:

- Patient encounters where the facility was more than 100 miles from the patient's home county, as most emergencies are reported to occur within a few miles of a patient's residence (Hsia, Kanzaria, et al., 2012; J. Lee et al., 2007). The County Distance Database from the National Bureau of Economic Research was used to compare patient state/county FIPS codes ("PSTCO") to the hospital state/county FIPS codes ("HFIPSSTCO") for the SID and SEDD data (National Bureau of Economic Research (NBER), 2016). Data from the second study state were provided as only including these encounters.

- Patient encounters resulting from a transfer from a different acute care hospital or other type of health care facility as noted by an existing variable ("TRAN_IN") or calculated using variable(s) indicating a patient's admission source. This was to avoid potential confounding that could result from inclusion of duplicate encounters between hospitals for one episode of care or from uncertainty in interventions or transfer protocols that may have directed early intervention and/or the transfer of care from other types of health care facilities (Hashmi et al., 2019).
- Pediatric patient encounters (ages 17 and younger), due to the population's different care needs as well as the low likelihood of being admitted for an emergency care sensitive condition (C. Liu et al., 2014).

Definitions of Emergency Care Sensitive Conditions (ECSCs)

For the purpose of this research, emergency care sensitive conditions (ECSCs) include the following conditions: acute myocardial infarctions (AMI) to include ST-elevated myocardial infarctions (STEMI), acute ischemic stroke, sepsis, and trauma. In order to select encounters with these conditions in the study sample, diagnoses codes from the SID, SEDD, and other state data were identified. For the data from years 2010-2014, *International Classification of Diseases, 9th Revision* (ICD-9-CM) diagnoses anywhere in the patient encounter were utilized to identify ECSC diagnoses. For the 2015 data, the dataset included both ICD-9-CM and the official *International Classification of Diseases, 10th Revision* (ICD-10-CM) coding due to the transition to ICD-10 on October 1, 2015. Thus, the 2015 data were analyzed accordingly to identify ECSC encounters anywhere in the patient encounter. For the 2016 data, ECSC encounters were identified anywhere in the patient record using ICD-10-CM diagnoses codes only. The literature was used to identify appropriate diagnoses codes for each of the selected ECSCs (Table 3.3). Encounters with multiple ECSCs were further excluded from the final study sample. Figure 3.1 illustrates the methodological map for the final sample selection.

Table 3.3 Emergency care sensitive conditions ICD-9-CM and ICD-10-CM coding

ECSC	**ICD-9-CM Codes (reference)**	**ICD-10-CM Codes (reference)**
AMI/STEMI	**410.X** (Mehta et al., 1999)	**I21, I22** (Workgroup for Electronic Data Interchange (WEDI), 2012)
Acute Ischemic Stroke	**430, 431, 434, 436** (McCormick, Bhole, Lacaille, & Avina-Zubieta, 2015)	**I60, I61, I63, I64** (McCormick et al., 2015)
Sepsis	**038.X, 995.91, 995.92, 785.52** (Wiedemann, 2007)	**A40.0-A41.9, R65.20, R65.21** (Wiedemann, 2007)
Trauma	**800.00 to 959.99 excluding 905-909, 910-924, and 930-939** (American College of Surgeons (ACS) Committee on Trauma (COT), 2015)	**S00-S99 (A,B,C), T07, T14, T20A-T28A, T30-T32, T79.A1-T79.A9** (ACS COT, 2015)

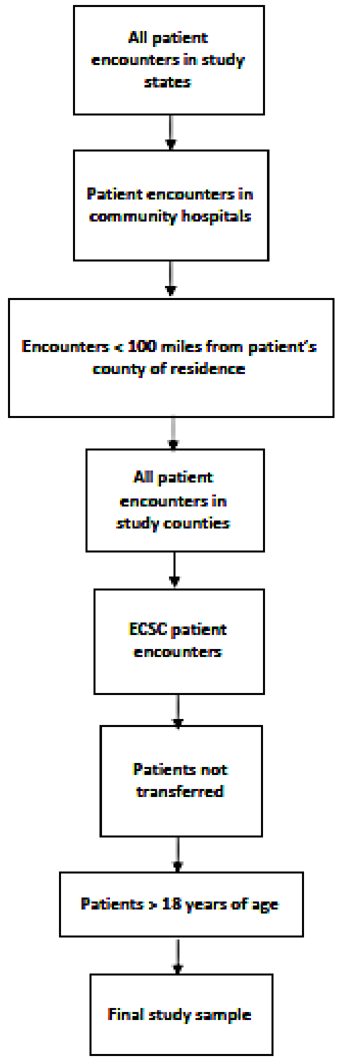

Figure 3.1 Methodological map of study sample selection

Study Variables

The dependent variable for research questions 1 and 2 was "died during hospitalization" ("DIED") to indicate in-hospital mortality. This may include encounters where the patient expired en route to the ED as these cases are still registered once they arrive in at least one of the study states (Dr. Jeff Hall, personal communication, September 11, 2018). For research question 3, the dependent variable was "died within

30-days" to indicate encounters that resulted in mortality within 30-days of hospital discharge. The primary independent variable of interest for all three research questions was the status of the rural hospital in the county where the patient encounters originated. A dummy variable was created to code counties from patient encounters associated with a rural hospital closure as 1, no hospital in the county as 2, and all else as 0.

Other variables of interest that were controlled for in the model included patient characteristics and hospital characteristics associated with encounters. For patient characteristics, the patients' age ("AGE"), gender ("FEMALE"), race/ethnicity ("RACE"), and expected payment source ("PAY1") were all included as demographic indicators that may impact access to health care (Buchmueller et al., 2006; Joynt et al., 2015; L. Liu et al., 2001; Ly et al., 2011; Villapiano et al., 2017). Further, patients' mortality risk by encounter was controlled for using the Charlson comorbidity index; the index variable was created using ICD-9-CM and ICD-10-CM diagnoses codes (Charlson, Pompei, Ales, & MacKenzie, 1987; Stagg, 2006). ED services provided ("HCUP_ED") during each encounter were also included as a measure of ED utilization (Abualenain et al., 2013; Hsia, Kanzaria, et al., 2012).

For research question 1, the primary hospital characteristic that was included as a control in the model was the status of state Medicaid expansion. This expansion of benefits, as previously stated, has been associated with fewer rural hospital closures in states (Bastain et al., 2016; Lindrooth et al., 2018). A dummy variable was created as a proxy for Medicaid expansion in the study sample. Encounters occurring after January 1, 2014 in the expansion state were considered to be under Medicaid expansion; encounters prior to that date were not. A variable to indicate the state where the hospital encounters occurred was also included to account for variations in other infrastructure between states, such as regionalization of care or other health care reimbursement considerations.

Study Design

A quasi-experimental difference-in-difference-in-difference (DDD) study design was utilized to compare mortality associated with patient encounters to hospitals and EDs from residents in counties that experienced rural hospital closures or from comparison counties. Accounting for the timing of the rural hospital closures is an important facet of the DDD design. Additionally, the timing variable is key to identify trends that may have been observed in the absence of the closure as well as trends associated with pre- and post-closure lagging effects (Hsia, Kanzaria, et al., 2012; L. Liu et al., 2001; Rosenbach & Dayhoff, 1995).

Thus, the time variable discharge quarter ("DQTR") was used to determine outcomes on a quarterly basis starting 24 months prior to each closure year and ending 24 months after each closure year for a total five-year study period as previously done by Kozhimannil et al. (2018). Both of the rural hospital closures included in the study occurred during Quarter 2 of the year of their closure. The discharge quarter variable was used to create a time variable that represented the pre-closure time period (quarters 1-9 of the study) and the post-closure time period (quarters 11-20). This arrangement also helped to account for potential seasonal fluctuations in encounter types or numbers.

Analytic Approach

Research Question 1: Examining all ECSC encounters as a group, is there a difference in in-hospital mortality during ECSC encounters for residents living in rural counties that *experienced a hospital closure compared to residents living in rural counties that did not experience a hospital closure?*

For research question 1, all patient encounters with any of the four defined ECSCs were included in the overall model. Differences in mortality at the encounter level were assessed per quarter per comparison group: (A) rural hospital closure occurred, (B) no rural hospital closure occurred, and (C) no hospital was present. Bi-variate analyses compared the relationships in the pre-closure time period between the comparison groups, patient and hospital characteristics, and mortality outcomes using chi-square (χ^2), one-way analysis of variance (ANOVA), and logistic regression. In-hospital mortality rates by study county were calculated for each quarter as a proportion of the total number of encounters.

A DDD logistic regression analysis was used to assess the change in mortality by determining the coefficients of the interactions between the time period and rural hospital closure status, in both unadjusted and adjusted models, while controlling for patient and hospital characteristics (Columbia University Mailman School of Public Health, n.d.). This enabled accounting for as much bias as possible in the model. The model equation is as follows:

(1) Y (in-hospital mortality) = $\beta_0 + \beta_1$*[post-closure time period] + β_2*[closure status] + β_3*[post-closure time period*closure status] + β_4*(age) + β_5*(gender) + β_6*(race) + β_7*(patient's payment source) + β_8*(Charlson comorbidity score) + β_9*(ED utilization) + β_{10}*(encounter during Medicaid expansion) + β_{11}*(state) + β_{12}*(AMI diagnosis) + β_{13}*(stroke diagnosis) + β_{14}*(sepsis diagnosis) + β_{15}*(trauma diagnosis) + ε

Research Question 2: Does a difference in in-hospital mortality associated with rural hospital closure vary among specific ECSC diagnoses?

For research question 2, the contributions of each ECSC were considered in one overall model with a triple interaction term. Essentially the model from research question 1 was utilized without addition of the covariates. Added was an interaction between the post-closure time period, rural hospital closure status, and ECSC diagnosis, which was analyzed using a DDD logistic regression. The model equation is as follows:

(2) Y (in-hospital mortality) = $\beta_0 + \beta_1$*[post-closure time period] + β_2*[closure status] + β_3*[post-closure time period*closure status] + β_4*[ECSC diagnosis] + β_5*[post-closure time period*ECSC diagnosis] + β_6*[closure status*ECSC diagnosis]+ β_7*[post-closure time period*closure status*ECSC diagnosis] + ε

Research Question 3: Is there an overall difference in 30-day post hospital discharge mortality associated with ECSC encounters for residents living in a rural county that experienced a hospital closure compared to residents living in rural counties that did not experience a hospital closure?

For research question 3, patient encounters from one state only with any of the four defined ECSCs were included in the overall model. Encounters that indicated in-hospital mortality were removed from the study sample to select for post hospital discharge mortality within 30-days only. These differences were assessed at the encounter level per quarter per comparison group: (A) rural hospital closure occurred, (B) no rural hospital closure occurred, and (C) no hospital was present.

Bi-variate analyses compared the relationships in the pre-closure time period between the comparison groups, patient characteristics, and 30-day post hospital discharge mortality outcomes using chi-square (χ^2), one-way analysis of variance (ANOVA), and logistic regression. Rates of 30-day post hospital discharge mortality by study county were calculated as a proportion of the total number of encounters for each quarter. A DDD logistic regression analysis was used to assess the change in mortality by determining the coefficients of the interactions between the time period and rural hospital closure status, in both unadjusted and adjusted models (while controlling for patient characteristics). The model equation is as follows:

(3) Y (30-day post hospital discharge mortality) = β_0 + β_1*[post-closure time period] + β_2*[closure status] + β_3*[post-closure time period*closure status] + β_4*(age) + β_5*(gender) + β_6*(race) + β_7*(patient's payment source) + β_8*(Charlson comorbidity score) + β_9*(ED utilization) + β_{10}*(AMI diagnosis) + β_{11}*(stroke diagnosis) + β_{12}*(sepsis diagnosis) + β_{13}*(trauma diagnosis) + ε

Sensitivity Analysis

In order to assess the ability of the models to accurately capture mortality from ECSC encounters as an outcome associated with rural hospital closure, an additional analysis was performed using conditions that do not require timely interventions but that may still have expected in-hospital mortality. Buchmueller and colleagues in a similar comparison assessed mortality from chronic heart disease, lung and colon cancer, chronic obstructive pulmonary disease (COPD), diabetes, and Alzheimer's disease (2006). For this study, congestive heart failure, COPD, and diabetes were chosen to be utilized in a model that replicated the analysis for research question 1. Appendix A includes the ICD-9-CM and ICD-10-CM diagnoses codes used for this analysis as well as the results.

All study analyses were completed using Stata SE, version 15 (StataCorp, 2017).

Institutional Review Board

The University of South Carolina Institutional Review Board evaluated this project and declared it "Not Human Research" on November 5, 2018.

CHAPTER 4

MANUSCRIPT ONE

THE ASSOCIATION OF RURAL HOSPITAL CLOSURES WITH DECLINING IN-HOSPITAL MORTALITY FROM EMERGENCY CARE SENSITIVE CONDITIONS[1]

[1] Merrell, M.A., Probst, J.C., Bennett, K.J., Olatosi, B.A., Hall, J.W. To be submitted to *The Journal of Rural Health*.

Abstract

Purpose

U.S. rural hospital closures have been increasing over the past decade. Limited access to health care services for affected populations may have dire consequences, including death. This study examined the association between rural hospital closures and in-hospital mortality in patient encounters for emergency care sensitive conditions (ECSCs).

Methods

Two rural hospital closures were identified as targets for selection of the study population. The counties where these closures occurred were matched to comparison counties that did and did not have a hospital. Adult patient encounters for acute myocardial infarction (AMI), stroke, sepsis, and trauma for residents of the study counties were assessed using a difference-in-difference-in-difference study design over a total five-year period. Patient characteristics were used to adjust the study model.

Findings

In-hospital mortality during the time period prior to the rural hospital closures was 8.2% among the study population. Over the entire study period, the in-hospital mortality rate from ECSCs for all study counties decreased significantly. However, the rate of decline was significantly greater in the post-closure time period among residents of counties where rural hospital closures occurred, following an initial increase in in-hospital deaths the first quarter post-closure. This finding did not vary by individual ECSC diagnosis.

Conclusions

The post-closure time period difference in in-hospital mortality associated with ECSCs among residents of counties that experienced rural hospital closures suggests initial

delays in care for ECSCs followed by a rapid rebound in access to needed services. More research is needed to clarify this association and to determine any specific impacts to vulnerable populations.

Keywords: rural health, hospital closure, mortality, emergency care sensitive conditions

Introduction

The U.S. is currently experiencing a disturbing trend of a rising number of rural community hospital closures (Kaufman, Thomas, et al., 2016). Since 2010, over 100 rural community hospitals have closed (Sheps Center, 2019). These closures increase the distance rural populations must travel to receive certain health care services, which may reduce utilization and delay access to timely care (Arcury et al., 2004; Basu, 2005; Buchmueller et al., 2006; Carr et al., 2009; Henderson & Taylor, 2003; Hsia, Kanzaria, et al., 2012; Nemet & Bailey, 2000; Moy et al., 2017; Troske & Davis, 2019). Decreased access to health care services in rural populations may directly contribute to negative health outcomes, especially among older adults, those in poverty, and among racial and ethnic minority groups (Bastain et al., 2016; Basu & Cooper, 2000; Bindman et al., 1990; Ly et al., 2011).

There is very little in the literature that specifically links rural hospital closures to health outcomes, especially mortality, among affected populations. Illnesses that are time-sensitive, such as heart attacks or unintentional injuries (otherwise known as emergency care sensitive conditions (ECSCs)), are subject to the "golden hour"; the time to intervention influences overall outcome (Carr et al., 2010; JEMS, 2012). Timely treatment of these illnesses in the emergency department (ED) is shown to result in decreased morbidity and mortality overall (Bernstein et al., 2009; Dresden, 2013; Kocher et al., 2013; Sharp et al., 2014). Treatment of ECSCs in high-volume EDs has also been associated with lower in-hospital mortality, potentially related to the quality of care received at the treatment facility (Kocher et al., 2014). Due to the increased distance and travel times to reach services, as well as complications from limited access to emergency specialty care and capability of emergency medical services, the "golden hour" may be difficult to achieve after a rural hospital closure has occurred (Moy et al., 2017; Troske & Davis, 2019).

If increasing mortality from ECSCs results in overall increased mortality for populations affected by rural hospital closure, geographic disparities in health outcomes between rural and urban populations in the U.S. may intensify (Hoffman & Holmes, 2017; James, 2014; Mansfield et al., 1999; Meit et al., 2014; Moy et al., 2017; Singh & Siahpush, 2014; Villapiano et al., 2017). Therefore, the aim of this study is to examine the association of rural hospital closures with in-hospital mortality from selected ECSCs. The most common ECSCs and the most dependent on efficient and timely access to definitive care for rural residents are acute myocardial infarction, acute ischemic stroke, sepsis, and trauma. Two U.S. states with rural hospital closures during the past decade were the targets for secondary data analyses.

Methodology

Population Studied

For this study, inpatient and ED patient encounters for ECSCs were analyzed by patients' county of residence linked to rural hospital status to identify differences in in-hospital mortality. Aside from a rural hospital closure occurring in the county of residence, the other options for hospital status were either open or none at all. Two U.S.

states were chosen for this study, and one rural hospital closure per state was identified: one in 2012 and one in 2014. One of the study states expanded its Medicaid program in 2014 as a result of the Affordable Care Act; the other did not (Henry J. Kaiser Family Foundation (KFF), n.d.).

ECSC patient encounters were identified from the study population for a period beginning two years prior to the closures and up to two years after closures, for a total study period of five years as previously done by Kozhimannil et al. (2018). Since each closure occurred during Quarter 2 of the year of closure, it was logical to select data from the closure year as well as for two years prior to and for two years after the closure year to obtain encounters for the entire study period. The primary aim of the study was to determine if there was a difference in in-hospital mortality during ECSC encounters for residents of rural counties that experienced a hospital closure compared to rural counties that did not experience a closure. A secondary aim sought to identify if differences in in-hospital mortality varied by specific ECSC diagnosis.

Data Sources

Three primary data sources were utilized for this study. Patient encounter data for one state were obtained from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP) State Inpatient and State Emergency Department Databases (Agency for Healthcare Research and Quality, n.d.). Data for calendar years 2012-2016 were obtained from the HCUP Online Central Distributor. Patient encounter data for the second study state were obtained from the state's all-payer claims database system, which is required by state statute to collect and maintain uniform billing data from acute care facilities. Data for calendar years 2010-2014 were obtained for analysis. U.S. Census data were used to match closure counties with comparison counties across both states having similar demographic characteristics.

Definition of Study Counties

Data from the Cecil G. Sheps Center for Health Services Research at The University of North Carolina at Chapel Hill were used to identify two permanently closed rural hospitals for the study sample (Sheps Center, 2018). The study population subject to rural hospital closure was defined as residents of counties in which a rural hospital was reported as closed and for which patient encounter data was available for the entire study period.

To differentiate the effects of the rural hospital closures from ongoing trends in patient mortality, eight comparison counties, four per state, were chosen. Data from the 2010 U.S. Census were used to match comparison counties to closure counties based on demographic information collected prior to the closures. Four county-level characteristics were used to match counties: population density, median household income, percent minority population, and percent elderly population (Ly et al., 2011; Rosenbach & Dayhoff, 1995). Dendrograms were created using median linkage clustering analysis to identify matches (Rosenbach & Dayhoff, 1995). Matches adjacent to closure counties and/or located on a state border were excluded and the next closest match based on population density was chosen (Rosenbach & Dayhoff, 1995).

Matched counties were further described by the operational status of their local hospital using state licensure data and/or confirmed through communication with the State Office of Rural Health in each state. Two counties with an open hospital and two counties where there is no hospital (or at least has not been operating for the past thirty years) were chosen per state for comparison (Rosenbach & Dayhoff, 1995). Since the 1980s included a large number of rural hospital closures, thirty years was chosen as a realistic cut-off point to ensure enough counties were available for matching. One-way analysis of variance (ANOVA) tests were used to confirm that there were no significant differences in demographic characteristics between the study counties. Patient encounters from each of the comparison counties were included in the study sample.

Table 4.1 Demographic characteristics of study counties and other counties in both studied states, U.S. Census 2010

	Comparison Counties – Open Hospital (n = 4)	**Comparison Counties – No Hospital (n = 4)**	**Closure Counties (n = 2)**	**Other counties in states (n = 156)**
Population density (per square mile)	47.18	38.75	39.5	123.8
65yrs+ Population (%)	17.1	16.4	15.8	14.4
Minority Population (%)	25.2	23.8	33.7	16.6
Median household income ($)	34,600	37,786	36,399	37,564

Study Definitions

Patient encounters were included in the study sample if (1) the patient's county of residence was in one of the ten study counties, identified using the patient's recorded county FIPS code; (2) the patient encounter occurred in a community hospital; and, (3) the patient encounter was for one of four ECSC diagnoses, as outlined below. Criteria for excluding encounters from the study sample included (1) patient encounters where the facility was more than 100 miles from the patient's home county, as most emergencies are reported to occur within a few miles of a patient's residence (Hsia, Kanzaria, et al., 2012; J. Lee et al., 2007; NBER, 2016); (2) encounters that were the result of a transfer from a different acute care hospital or another other type of health care facility, to avoid potential duplication of encounters related to one event and/or unknown treatments provided before or during transport (Hashmi et al., 2019); or, (3) pediatric patient encounters (ages 17 and younger), due to the population's different care needs as well as the low likelihood of being diagnosed with an ECSC (C. Liu et al., 2014). Figure 4.1 outlines the resulting methodological map.

For this study, ECSCs included acute myocardial infarctions (AMI) to include ST-elevated myocardial infarctions (STEMI), acute ischemic stroke, sepsis, and trauma. Diagnosis codes from anywhere in the patient encounter (primary diagnosis or otherwise) were used to identify these conditions in the data. For years 2010-2014, codes from the official *International Classification of Diseases, 9th Revision* (ICD-9-CM) were used. For 2015, the data included codes from both ICD-9-CM and the official *International Classification of Diseases, 10th Revision* (ICD-10-CM) due to the transition to ICD-10 on October 1, 2015; for 2016, only the ICD-10-CM diagnosis codes were needed. Sources used to identify appropriate ICD-9-CM and ICD-10-CM codes for each of the ECSCs are noted in the table (4.2).

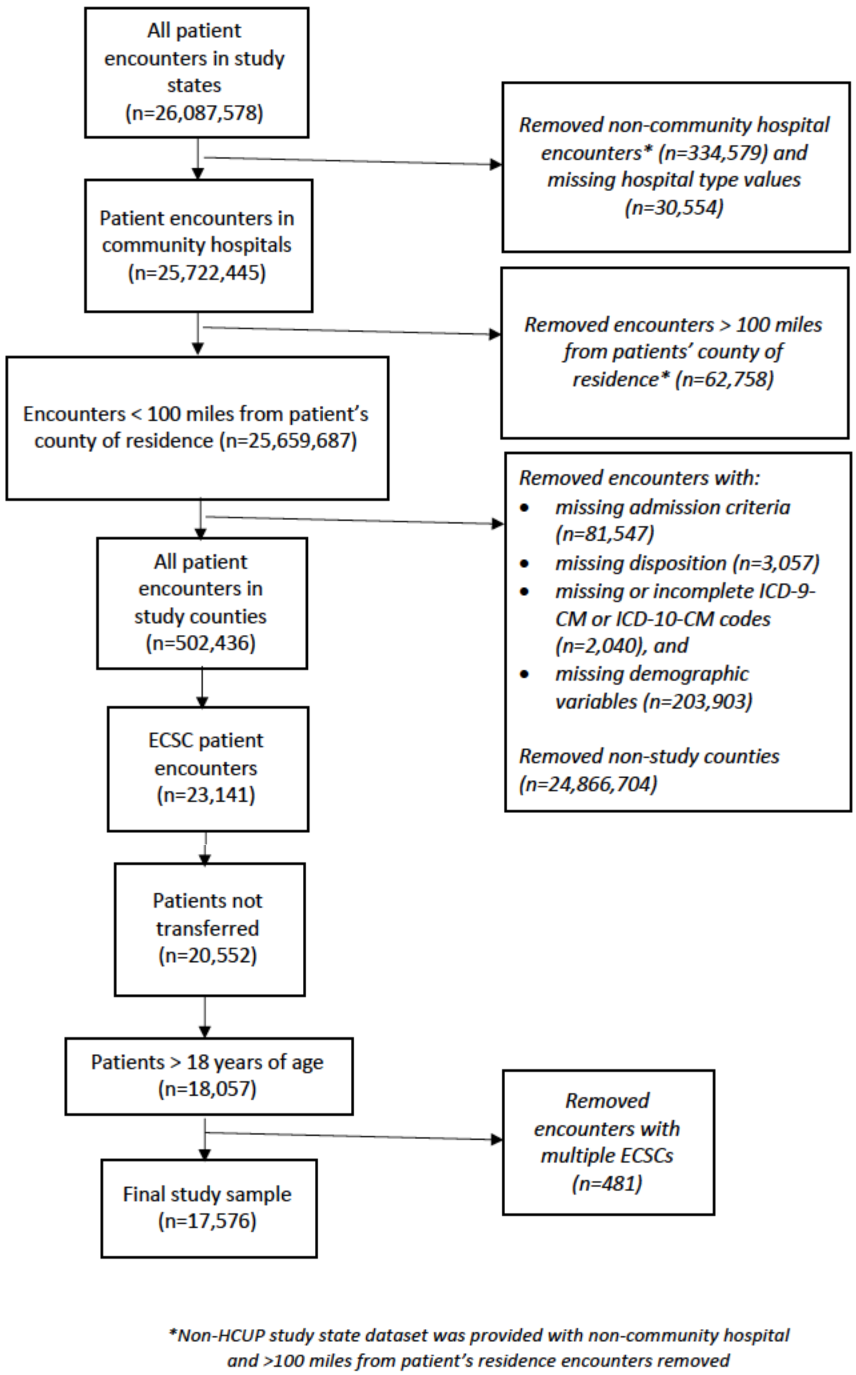

Figure 4.1 Study sample map

Table 4.2 Emergency care sensitive conditions ICD-9-CM and ICD-10-CM coding

ECSC	**ICD-9-CM Codes (reference)**	**ICD-10-CM Codes (reference)**
AMI/STEMI	**410.X** (Mehta et al., 1999)	**I21, I22** (WEDI, 2012)
Acute Ischemic Stroke	**430, 431, 434, 436** (McCormick et al., 2015)	**I60, I61, I63, I64** (McCormick et al., 2015)
Sepsis	**038.X, 995.91, 995.92, 785.52** (Wiedemann, 2007)	**A40.0-A41.9, R65.20, R65.21** (Wiedemann, 2007)
Trauma	**800.00 to 959.99 excluding 905-909, 910-924, and 930-939** (ACS COT, 2015)	**S00-S99 (A,B,C), T07, T14, T20A-T28A, T30-T32, T79.A1-T79.A9** (ACS COT, 2015)

Study Design

A quasi-experimental difference-in-difference-in-difference (DDD) study design was utilized to compare in-hospital mortality associated with ECSC patient encounters. In-hospital mortality was calculated for each discharge quarter for a total five-year study period. The pre-closure time period was calculated as the nine quarters prior to the rural hospital closure occurring; post-closure was calculated as the ten quarters after the quarter in which the rural hospital closure occurred.

The dependent variable for the study was in-hospital mortality, whether it occurred in the ED or inpatient service. The primary independent variable of interest was the status of the hospital in the patient's county of residence: closed, open, or none. Patient demographic and clinical variables were included in adjusted models. Patient demographic characteristics (age, gender, race/ethnicity, and expected payment source) were all included as indicators that may impact access to health care (Buchmueller et al., 2006; Joynt et al., 2015; L. Liu et al., 2001; Ly et al., 2011; Villapiano et al., 2017). Patients' mortality risk by encounter was adjusted using the Charlson comorbidity index (Charlson et al., 1987; Stagg, 2006). ED utilization for each encounter was also included (Abualenain et al., 2013; Hsia, Kanzaria, et al., 2012).

Two hospital characteristics were also included in the model: the state where the hospital was located and the status of state Medicaid expansion as a result of the Patient Protection and Affordable Care Act (ACA). This expansion of benefits has been associated with fewer rural hospital closures in states, possibly due to rural hospitals providing less uncompensated care as compared to non-expansion states (Bastain et al., 2016; Lindrooth et al., 2018; Kaufman, Reiter et al., 2016). Encounters occurring after January 1, 2014 in the expansion state were coded as under Medicaid expansion; encounters prior to that date or in the non-expansion state were not.

Analytic Approach

All patient encounters with any of the four defined ECSCs were included in the overall model except for encounters with multiple ECSCs, which were further excluded (n=481), leaving a total number of encounters in the study population of n=17,576. Encounter characteristics in the pre-closure time period were calculated and assessed for statistically significant differences between the study counties using chi-square (χ^2) and one-way analysis of variance (ANOVA) tests. Bi-variate analyses to compare in-hospital mortality and encounter characteristics in the pre-closure time period were also performed using χ^2, ANOVA, and logistic regression tests. In-hospital mortality for each quarter by study county was calculated as a proportion of the total number of deaths per the total number encounters in both the pre-closure and post-closure time periods. The closure quarter was omitted from the figures of these data to provide clear demarcations of the pre- and post-closure time periods.

Logistic regression was used to assess differences in in-hospital mortality prior to and after the rural hospital closure occurred, with and without adjusting for patient and hospital characteristics. A logistic regression analysis was also completed that assessed differences in in-hospital mortality between individual ECSCs. Finally, a sensitivity analysis was performed, replicating the primary logistic regression model using the non time-sensitive conditions of chronic heart disease, chronic obstructive pulmonary disease (COPD), and diabetes (Buchmueller et al., 2006). All analyses were completed using Stata SE, version 15 (StataCorp, 2017). The University of South Carolina Institutional Review Board declared this study Not Human Research on November 5, 2018.

Results

In the pre-closure time period, there were 5,040 patient encounters related to an ECSC in the studied counties; this represents an encounter rate of 134.96 per 10,000 population. Of these, 8.2% (n=413) resulted in in-hospital mortality; there was no significant difference in in-hospital mortality between study counties (p=0.292). By diagnosis, 23.3% of pre-closure time period encounters in the sample were for AMI; 22.3% were for acute ischemic stroke, 39.1% were for sepsis, and 15.3% were for trauma. There were significant differences among the study counties for each diagnosis. AMI and sepsis diagnoses were higher for patient encounters from counties that experienced a closure and/or that did not have a hospital; stroke and trauma diagnoses were higher for patient encounters from comparison counties with hospitals (Table 4.3).

The mean patient age in all pre-closure time period ECSC encounters was 62.8; a higher proportion were by men (52.4%). A majority of all pre-closure time period ECSC encounters were made by whites (67.3%) and by Medicare recipients (56.4%). Pre-closure time period ECSC encounters that included an initial patient encounter in an ED accounted for 45.2% of all visits. This was significantly different for patient encounters among the study counties with the highest number (52.2%) occurring in counties without a hospital (p=0.000).

Several patient characteristics were significantly associated with in-hospital mortality during the pre-closure time period: age, gender, race, payment source, Charlson Index mean score, and Emergency Department utilization during the encounter (Table 4.4). Of patients who died (n=413), the mean age was 71.9 and the mean Charlson Index score was 3.0. In-hospital mortality among females in the study population was 9.3% (versus 7.2% among males). Among all patients of Black race, in-hospital mortality was 9.8% (versus 7.3% for white patients). By patient's payment source, 10.2% of Medicare recipients died in-hospital (versus 7.1% of Medicaid recipients, 6.8% of private pay patients, 2.3% of self-pay patients, and 5.9% of patients with another source of payment). Of those who utilized the ED during their encounter, 4.2% died in-hospital. Diagnosis of any ECSC was also significantly associated with in-hospital mortality as expected. In the pre-closure time period, 6.1% of diagnosed AMI encounters, 5.3% of diagnosed stroke encounters, 14.0% of diagnosed sepsis encounters, and 0.8% of diagnosed trauma encounters resulted in in-hospital mortality.

Table 4.3 Characteristics of patient encounters by closure status, pre-closure time period

	All studied visits (n=5,040)	**Visits by closure status**			
		Comparison Counties – Open Hospital (n=2,659)	**Comparison Counties – No Hospital (n=1,576)**	**Closure Counties (n=805)**	
Characteristics of visit population		*Averages*	*Averages*	*Averages*	*P value for comparison*
Died In-Hospital (% yes)	8.2	8.2	8.8	7.0	0.292
Age (mean)	62.8	62.7	63.1	62.5	0.718
Gender (% female)	47.6	47.0	46.0	52.6	**0.007**
Race (% white)	67.3	66.3	75.2	55.0	**0.000**
(% black)	31.1	31.9	23.3	43.9	**0.000**
(% other)	1.6	1.8	1.5	1.1	0.421

Payment Source (% Medicare)	56.4	53.5	61.2	56.7	**0.000**
(% Medicaid)	9.6	10.9	7.7	8.9	**0.002**
(% private)	18.6	17.9	18.3	21.4	0.077
(% self-pay)	11.1	13.2	8.4	9.8	**0.000**
(% other)	4.4	4.6	4.5	3.2	0.224
Charlson Index (mean)	2.0	1.8	2.3	2.1	**0.000**
ED Utilization (% yes)	45.2	40.8	52.2	45.8	**0.000**
Medicaid Expansion (% yes)	4.0	3.5	5.8	2.0	**0.000**
AMI Diagnosis (% yes)	23.3	22.1	26.0	22.4	**0.012**
Stroke Diagnosis (% yes)	22.3	24.7	18.0	23.1	**0.000**
Sepsis Diagnosis (% yes)	39.1	36.0	43.9	39.9	**0.000**
Trauma Diagnosis (% yes)	15.3	17.3	12.3	14.7	**0.000**
Bold type: Significant at < p=0.05.					

Table 4.4 Patient characteristics associated with in-hospital mortality, pre-closure time period

Characteristics of visit population (n=5,040)	**% died**	**P value**	**ORs**	**95% CI**
Died In-Hospital (% yes)	8.2 (n=413)	--	--	--
Age (each additional year)	--	--	**1.04**	1.029, 1.043
Gender				
Female (n=2,398)	9.3 (n=223)	**0.006**	**1.32**	1.081, 1.619
Male (n=2,642)	7.2 (n=190)	**0.006**	--	--
Race				
White (n=3,392)	7.3 (n=248)	**0.001**	--	--
Black (n=1,568)	9.8 (n=154)	**0.005**	**1.38**	1.118, 1.704
Other (n=80)	13.8 (n=11)	0.068	**2.02**	1.056, 3.869
Payment Source				
Medicare (n=2,842)	10.2 (n=289)	**0.000**	--	--
Medicaid (n=482)	7.1 (n=34)	0.337	**0.67**	0.463, 0.970
Private (n=935)	6.8 (n=64)	0.096	**0.65**	0.490, 0.860

Self-pay (n=561)	2.3 (n=13)	**0.000**	**0.21**	0.119, 0.368
Other (n=220)	5.9 (n=13)	0.206	**0.55**	0.313, 0.984
Charlson Index (mean)	--	--	**1.22**	1.170, 1.269
ED Utilization (yes versus no) (n(yes)=2,278)	4.2 (n=95)	**0.000**	**0.33**	0.264, 0.424
Medicaid Expansion (yes versus no) (n(yes)=200)	6.0 (n=12)	0.248	0.71	0.391, 1.278
AMI Diagnosis (yes versus no) (n(yes)=1,176)	6.1 (n=72)	**0.003**	**0.67**	0.518, 0.877
Stroke Diagnosis (yes versus no) (n(yes)=1,125)	5.3 (n=60)	**0.000**	**0.57**	0.429, 0.754
Sepsis Diagnosis (yes versus no) (n(yes)=1,968)	14.0 (n=275)	**0.000**	**3.45**	2.791, 4.273
Trauma Diagnosis (yes versus no) (n(yes)=771)	0.8 (n=6)	**0.000**	**0.07**	0.033, 0.167

OR: Odds Ratio; CI: Confidence Interval; ED: Emergency Department; AMI: Acute Myocardial Infarction

Bold type: significant at < p=0.05.

In the post-closure time period, the average in-hospital mortality associated with ECSCs was 4.1% (n=491) compared to 8.2% in the pre-closure time period. In-hospital mortality in the post-closure time period did not differ significantly among the study counties (p=0.143). Figures 4.2 and 4.3 show the rates of in-hospital mortality per total encounters for each quarter of the study, divided between the pre-closure and post-closure time periods. In the pre-closure time period, the slopes of the regression lines for each of the study groups were not significantly different from each other (data not shown).

In the post-closure time period, the rates for each of the study groups appear to decline. This was confirmed by the logistic regression analysis that showed in-hospital mortality for all ECSC encounters was significantly less likely compared to the pre-closure time period (Table 4.5). Further, the rate of decline in in-hospital mortality related to ECSCs was significantly greater in the post-closure time period for residents of study counties that experienced a rural hospital closure compare to residents of counties that did not experience a rural hospital closure, as indicated by an odds ratio greater than 1 for the interaction term between time and closure status in the logistic regression analysis (Table 4.5). This difference in the rate of change of in-hospital mortality for residents of closure counties is also evident in Figure 4.3. The coefficients of the interaction variables in Table 4.5 represent the values of the DDD.

Adjusting for covariates in the analysis did not change this outcome. Covariates that were associated significantly with increased in-hospital mortality included age, Black race, other payment source, and mean Charlson Index score. ED utilization was significantly less likely to result in in-hospital mortality over the entire study period. The association of rural hospital closure with in-hospital mortality did not vary between diagnoses (Table 4.6). Finally, the sensitivity analysis revealed that overall in-hospital mortality declined significantly in the post-closure time period for selected non time-sensitive conditions, similar to the outcome associated with ECSC encounters. The rate of decline was significantly greater in the post-closure time period for residents of counties without a hospital in the unadjusted model and for residents of closure counties in the adjusted model (refer to Appendix A).

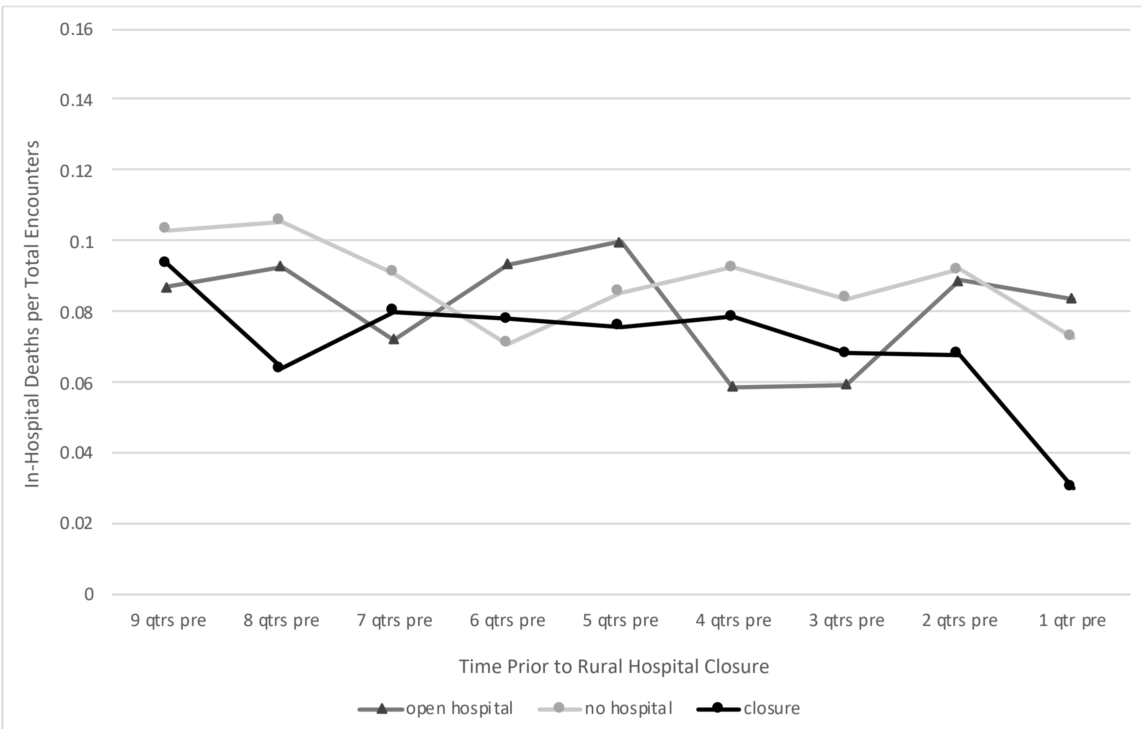

Figure 4.2 In-hospital mortality rates, pre-closure time period

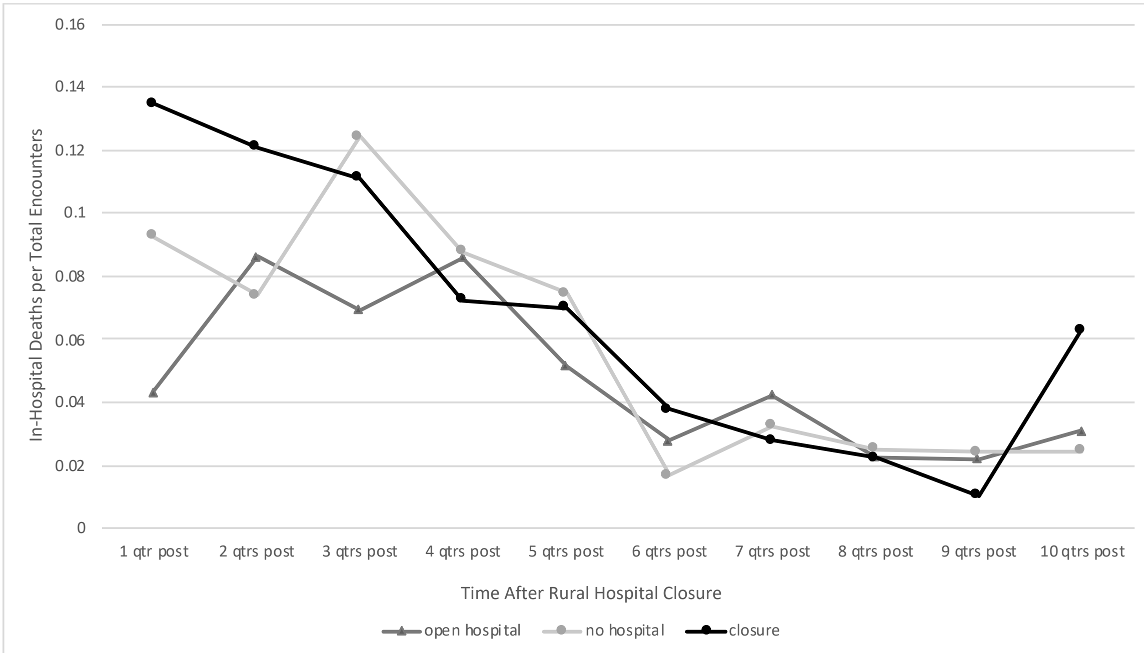

Figure 4.3 In-hospital mortality rates, post-closure time period

Discussion

In this study, in-hospital mortality rates of patient encounters from residents living in counties that experienced a hospital closure declined more rapidly in the period after the closure, whereas no change is seen in the rates for patient encounters emanating from comparison counties (either with or without hospitals). In the pre-closure time period, in-hospital mortality rates of patients residing in closure counties were similar to the rates seen for patients of comparison counties. However, in-hospital mortality for closure county residents spiked in the first quarter after the closure, increasing 0.105 compared to the last quarter before closure and 0.052 compared to the closure quarter. This initial increase in in-hospital mortality for residents of closure counties, with a return to a similar level to comparison counties by the final study quarter, supports the significant and rapid decline in in-hospital mortality over the post-closure time period.

Table 4.5 Logistic regression results, in-hospital mortality pre- and post-closure time periods

	Model 1 (No Covariates) (n = 17,576)			**Model 2 (With Covariates) (n = 17,576)**		
Dependent Variable: In-Hospital Mortality	*Coefficient*	*ORs*	*95% CI*	*Coefficient*	*ORs*	*95% CI*
Post-Closure Time Period	**-0.043**	**0.45**	0.377, 0.544	**-0.014**	**0.80**	0.652, 0.976
County Closure Status – Closed	-0.011	0.86	0.644, 1.147	-0.015	0.82	0.609, 1.110
County Closure Status – No Hospital	0.007	1.10	0.891, 1.360	0.001	1.05	0.840, 1.319
Post-Closure Time Period * Closed Status	**0.021**	**1.49**	1.020, 2.182	**0.022**	**1.53**	1.029, 2.280
Post-Closure Time Period * No Hospital Status	-0.005	0.97	0.719, 1.296	0.001	1.09	0.799, 1.494
Age	--	--	--	**0.001**	**1.04**	1.030, 1.042
Gender – Female	--	--	--	-0.002	0.97	0.840, 1.110
Race – Black	--	--	--	**0.013**	**1.27**	1.075, 1.498
Race – Other	--	--	--	0.015	1.44	0.788, 2.628
Payment Source – Medicaid	--	--	--	**0.013**	1.13	0.853, 1.499
Payment Source – Private	--	--	--	**0.011**	1.17	0.935, 1.472

Payment Source – Self	--	--	--	**0.016**	1.40	0.953, 2.056
Payment Source – Other	--	--	--	**0.034**	**2.41**	1.675, 3.454
Charlson Index	--	--	--	**0.014**	**1.17**	1.141, 1.209
ED Utilization	--	--	--	**-0.019**	**0.67**	0.540, 0.831
Medicaid Expansion	--	--	--	0.013	1.23	0.909, 1.670
State	--	--	--	-0.008	0.97	0.724, 1.303
AMI Diagnosis	--	--	--	-0.003	**8.17**	5.052, 13.216
Stroke Diagnosis	--	--	--	-0.012	**6.93**	4.247, 11.313
Sepsis Diagnosis	--	--	--	**0.697**	**19.4**	12.124, 30.915
Trauma Diagnosis	--	--	--	--	--	--
	Model p value = **0.0000**			Model p value = **0.0000**		
OR: Odds Ratio; CI: Confidence Interval; ED: Emergency Department; AMI: Acute Myocardial Infarction Bold type: significant at < p=0.05.						

Table 4.6 Logistic regression results, in-hospital mortality pre- and post-closure time periods with individual emergency care sensitive conditions

	Model 3 (No Covariates) (n = 17,576)	
Dependent Variable: In-Hospital Mortality	*ORs*	*95% CI*
Post-Closure Time Period	**0.21**	0.060, 0.763
County Closure Status – Closed	0.98	0.108, 8.831
County Closure Status – No Hospital	0.58	0.064, 5.187
Post-Closure Time Period * Closed Status	3.00	0.246, 36.590
Post-Closure Time Period * No Hospital Status	1.91	0.151, 24.069
Stroke Diagnosis	**7.23**	2.562, 20.375
Sepsis Diagnosis	**20.02**	7.367, 54.382
AMI Diagnosis	**10.88**	3.911, 30.266
Post-Closure Time Period * Stroke Diagnosis	**4.18**	1.085, 16.119
Post-Closure Time Period * Sepsis Diagnosis	**4.08**	1.119, 14.839

Post-Closure Time Period * AMI Diagnosis	3.63	0.962, 13.669
Closed Status * Stroke Diagnosis	0.54	0.050, 5.745
Closed Status * Sepsis Diagnosis	1.00	0.108, 9.320
Closed Status * AMI Diagnosis	0.50	0.048, 5.092
No Hospital Status * Stroke Diagnosis	2.31	0.241, 22.151
No Hospital Status * Sepsis Diagnosis	1.78	0.194, 16.275
No Hospital Status * AMI Diagnosis	1.21	0.127, 11.492
Post-Closure Time Period * Closed Status * Stroke Diagnosis	0.63	0.040, 9.803
Post-Closure Time Period * Closed Status * Sepsis Diagnosis	0.46	0.036, 5.918
Post-Closure Time Period * Closed Status * AMI Diagnosis	0.49	0.033, 7.265
Post-Closure Time Period * No Hospital Status * Stroke Diagnosis	0.68	0.048, 9.497
Post-Closure Time Period * No Hospital Status * Sepsis Diagnosis	0.52	0.040, 6.740
Post-Closure Time Period * No Hospital Status * AMI Diagnosis	0.64	0.046, 8.792
	Model p value = **0.0000**	
OR: Odds Ratio; CI: Confidence Interval; AMI: Acute Myocardial Infarction; Bold type: significant at < p=0.05.		

The increase in in-hospital mortality in the first quarter post-closure for residents of closure counties suggests potential delays in care as a result of the closure, which may be associated with poorer outcomes (Buchmueller et al., 2006; Fleming et al., 1995). Delays during this period may have resulted from confusion of the affected population and/or its health care providers (especially EMS) as to where to access emergency services in the aftermath of the closure. Interestingly, as suggested above, this confusion appears to be temporary, as the rapid decline in in-hospital mortality over the post-closure time period among residents of closure counties suggests a rebound in identifying available access to emergency services. Patient data for additional years post-closure would further clarify any ongoing trends in in-hospital mortality for these residents.

This significant association in the rate of decline of in-hospital mortality for residents of counties that experienced rural hospital closures was found in spite of significant differences between study counties' patient characteristics in the pre-closure time period. Patients from counties that experienced a closure were more likely female and Black in the period prior to closure. Patients from comparison counties with open hospitals were significantly more likely Medicaid recipients or self-pay patients during this period. Age, other race, and private insurance or other as payment sources were not significantly different among the three study counties in the pre-closure time period (Table 4.3).

Overall, patients who died in the hospital from ECSCs in this study were more likely to be older and sicker, which is a common attribute of rural populations (Tables 4.4 and 4.5). Significant differences in the association of gender with in-hospital mortality in the pre-closure time period were not found over the entire study period (Table 4.5).

Significant associations between race and in-hospital mortality in the pre-closure time period did however sustain throughout the entire study period. ECSC associated patient encounters among patients of Black race were 27% more likely to result in death in the hospital (Table 4.5). This aligns with other literature regarding populations that are exceptionally vulnerable to health care access issues (Friedman, 1990; McLafferty, 1982; S. R. Thomas et al., 2016).

In-hospital mortality rates related to admission for an ECSC diagnosis declined overall throughout the study period observed. This finding is in line with other reports that the overall in-hospital mortality for these conditions is mostly decreasing among U.S. populations (Albright et al., 2010; Jones et al., 2017; R. L. McNamara et al., 2016; Ovbiagele, 2010; Rivers et al., 2001). Further, the encounter rates for each condition are similar to those identified in previous studies (Egol, Tolisano, Spratt, & Koval, 2011; Jones et al., 2017; R. L. McNamara et al., 2016; Ovbiagele, 2010).

Interestingly, the odds of in-hospital mortality were significantly lower among patients that had an initial admission to the ED as part of their ECSC encounter (Tables 4.4 and 4.5). Work by Kocher and colleagues (2013) describing the role of EDs in unscheduled hospitalizations found that utilization of the ED for time-sensitive conditions resulted in decreased mortality and length of stay for patients. The ability of EDs to rapidly assess, treat, and manage these conditions is key. Others have also described the positive impact of early intervention for specific ECSCs (Canto et al., 2002).

For this study population, AMI and sepsis occurred most often, resulted in a higher proportion of patients with these conditions dying in-hospital, and contributed significantly to in-hospital mortality with odds ratios of 8.17 and 19.4 respectively over the entire study period. Stroke encounters were a close third in terms of diagnosis frequency and in-hospital mortality, and trauma encounters and deaths occurred least often. Although the severity of cases is unknown, it may be inferred that the low number of trauma deaths in particular is a result of robust systems of trauma care that have existed since the 1980s (Delgado et al., 2014; Hsia et al., 2010; MacKenzie et al., 2006). On the other hand, sepsis in particular appears to be of concern in this study population, with 14.0% of cases resulting in in-hospital mortality.

The frequencies of ECSC diagnoses were significantly different between the study counties in the pre-closure time period (Table 4.3). However, there was no variance in in-hospital mortality over the entire study period between individual ECSC diagnosis, which was an unexpected finding (Table 4.6). One explanation is that since ECSC diagnoses are time-sensitive by definition, it is reasonable that the significant effect of time in the study model would dominate over any between group differences. Future studies may consider matching patient encounters by ECSC diagnoses between study counties prior to analysis to clarify this finding.

Unfortunately, this study is unable to provide a full view of mortality related to ECSC diagnoses in the selected counties as no data are included in this study that explore any deaths prior to a hospital admission or after an admission and discharge have occurred. The overall crude mortality rate per 10,000 population in the study counties two years prior to the closures occurring was 122.5 for counties with open hospitals, 112.6 for counties without hospitals, and 127.9 for counties that later experienced closures (Centers for Disease Control and Prevention, National Center for Health Statistics, 2018). These crude rates changed very little relatively over the entire five-year study period, with an average increase overall of 4.37. While these rates are not specific to ECSCs, pre-treatment mortality (e.g. at home, prior to any interventions) has been reported to be higher than in-hospital mortality for certain populations, such as those experiencing trauma (Hashmi et al., 2019).

There are other reasons to consider mortality associated with rural hospital closures in a broader context. Patients in counties that experience hospital closure may delay care to the point that they die at home before attempting to seek care (Rosenbach & Dayhoff, 1995). Even those that do seek care may have complications after discharge that require another visit to a hospital – a visit that may be delayed or not happen at all. Also, there is no information in this study about the pre-hospital period, namely travel time to definitive care and whether the patient received medical intervention(s) en route if transported by EMS. These are potentially critical factors that must be assessed to understand the role they play in mortality associated with rural hospital closures.

Additional analyses that use more specific ECSC ICD-9-CM and/or ICD-10-CM coding may be useful for future studies as well. Given the broad definitions applied to this study, it is possible that there are conditions included within each of the four ECSC categories that are not explicitly time-sensitive. This is particularly noteworthy for the trauma encounters selected for this study as there is no ability to assess or assign severity of the accident or to know if trauma system activation was required. Likewise, additional diagnoses may need to be considered for populations affected by rural hospital closures. Conditions that are not formally categorized as ECSCs may still result in distressed patients with long commutes to definitive care. Pediatric patients, excluded from this study, are another population that may be negatively impacted by closures. It is important to understand how rural hospital closures may impact overall mortality in the short and long-term for these patient populations.

Certainly, more work to understand the effects of hospital closures on rural populations is warranted, especially related to mortality. This study only considers two rural hospital closures out of the over 100 that have occurred since 2010. There is an opportunity to look back at the closures from the 1980s to understand how people in those communities have fared over time. There is also an opportunity to better understand the associations occurring in the short-term for current closures. Vulnerable populations prior to a rural hospital closure (i.e. the elderly, the uninsured, the poor, those in need of emergency services, those without transportation, etc.), are at much greater risk for lack of access to health care after a closure occurs (Bindman et al., 1990; Fleming et al., 1995; McKay & Coventry, 1995; Mick & Morlock, 1990; Muus et al., 1995). Additional research is needed to quantify this risk, including related outcomes, to ensure the appropriate response is defined.

Limitations

For this study, one of the primary limitations was the relatively small number of study encounters. With only two rural hospital closures considered out of over 100, these data only represent a small fraction of the overall potential study population. More encounters would lessen the margin of error and narrow confidence intervals. Further, with only two states represented, the generalizability of the study results is restricted. However, the study states were in or near areas where a majority of the closures since 2010 have occurred (Kaufman, Thomas, et al., 2016).

As mentioned, very broad definitions of ECSCs were applied as inclusion criteria for patient encounters. This may have limited the study by introducing bias through misclassification. Related, this study was subject to variations in coding patterns due to the conversion from ICD-9-CM to ICD-10-CM in October 2015. Changes to the codes used to define ECSCs may have also introduced bias unintentionally to the study, also through misclassification (WEDI, 2012).

The inability to capture certain data elements was also a limitation. For instance, the hospital market patterns for the study counties were unknown and therefore not considered. Patient county of residence was instead used as a proxy for hospital service area, which is not a precise indicator of actual utilization. For example, the geographic constraints of using county boundaries as the hospital service area may estimate it as too small or too large depending on the rural hospital's reach. County boundaries also do not take into consideration roadways and ease of travel to other nearby hospital facilities. Given the time-sensitive nature of ECSCs, how far the next hospital facility is and whether or not it has the capacity to definitively treat the patient's exact condition are critical factors to consider as diversion has been associated with increased mortality odds among patients experiencing AMI and trauma (Begley et al., 2004; Shen, 2011).

Finally, excluding patient encounters where there was a transfer in from a long-term care facility may also limit the ability to understand the full picture of in-hospital mortality associated with rural hospital closures. Residents of these facilities are often transferred to the local rural hospital for assessment and stabilization. In the event of a closure of this local facility, these residents may be particularly vulnerable to receiving definitive care for ECSCs in a timely manner. A study that includes primary data collection may elucidate a more complete understanding of the association of rural hospital closures on mortality related to ECSC encounters for all types of patients.

Conclusion

While this study successfully describes the association of two rural hospital closures with in-hospital mortality related to emergency care sensitive conditions, more work is needed to fully understand this association. This is especially important for populations with these diagnoses as time is a critical element in assuring optimal treatment and patient outcomes. This study demonstrates that there is a small but significant effect for patient encounters from closure counties after a rural hospital closure occurs. This signifies a need to continue to monitor at-risk hospitals closely – to prevent closures whenever possible – and also to plan for how to address emergency care access needs in the event a closure does occur.

CHAPTER 5

MANUSCRIPT TWO

THE ASSOCIATION OF A RURAL HOSPITAL CLOSURE WITH 30-DAY POST HOSPITAL DISCHARGE MORTALITY[1]

[1] Merrell, M.A., Probst, J.C., Bennett, K.J., Olatosi, B.A., Hall, J.W. To be submitted to *The Journal of Rural Health*.

Abstract

Purpose

Recent rural hospital closures in the U.S. may be associated with adverse effects for residents in their service areas. Access to definitive care for emergency care sensitive conditions (ECSCs) may be delayed or otherwise compromised as a result of such closures, leading to complications including the potential for death. This study describes the case of one rural hospital closure and associated 30-day post hospital discharge mortality related to ECSC encounters for residents of the affected community.

Methods

Secondary data analyses were performed using adult patient encounters obtained from a statewide all-payer claims database in the state where the targeted rural hospital closure occurred. Residents of the closure county and four additional comparison counties, both with and without hospitals, were selected for study inclusion. Mortality within 30-days post discharge was obtained by linking individual encounters to death certificate data from the state's Vital Records department. A difference-in-difference-in-difference logistic regression analysis was utilized to examine the change in mortality rates between the pre- and post-closure time periods.

Findings

Mortality rates within 30-days post hospital discharge associated with an ECSC diagnosis did not change over the five-year study period for the entire study population. In the post-closure time period, 30-day mortality post hospital discharge for all residents experiencing an ECSC was 8.0%. For residents that experienced a rural hospital closure,

the 30-day post hospital discharge mortality rate slowed significantly in the time period following the closure.

Conclusions

These findings, from a case study of one rural hospital closure located in a Southeastern U.S. state, suggest several potential outcomes in the aftermath of the closure. More work is needed to identify if the change in the rate of 30-day post hospital discharge mortality associated with ECSC diagnoses is the result of improved access to quality care or an increase in delays in care for the affected population.

Keywords: rural health, hospital closure, 30-day mortality, emergency care sensitive conditions

Introduction

Over 100 rural hospitals have closed in the United States (U.S.) since 2010 (Sheps Center, 2019). Rural hospital closures increase the distance residents must travel to receive health care services, which reduces overall utilization and delays access to care (Arcury et al., 2004; Basu, 2005; Buchmueller et al., 2006; Carr et al., 2009; Henderson & Taylor, 2003; Hsia, Kanzaria, et al., 2012; Moy et al., 2017; Nemet & Bailey, 2000; Troske & Davis, 2019). Vulnerable populations, such as those who are older, live in poverty, and/or are a member of a racial or ethnic minority group, are at an even greater risk for poor health outcomes associated with closures (Bastain et al., 2016; Basu & Cooper, 2000; Bindman et al., 1990; Ly et al., 2011). However, little is known about how rural hospital closures may be associated with mortality among affected populations.

Emergency care sensitive conditions (ECSCs) are time-sensitive illnesses that require rapid intervention for optimal patient outcomes (Carr et al., 2010; JEMS, 2012).

Rapid intervention after a rural hospital closure may be limited due to the increased distance and travel times to reach services, and/or limited access to emergency specialty care or emergency medical services (Moy et al., 2017; Troske & Davis, 2019). Importantly, when timely treatment of these illnesses is achieved via an ED, associated morbidity and mortality decrease (Bernstein et al., 2009; Dresden, 2013; Kocher et al., 2013; Sharp et al., 2014). Yet, a longitudinal study of patients in New Jersey experiencing acute myocardial infarction (AMI) suggested that 30-day post hospital discharge mortality as well as 1-year post discharge mortality may be increasing over time (Kostis, Deng, Pantazopoulos, Moreyra, & Kostis, 2010).

Thirty-day post hospital discharge mortality rates are useful in comparing quality outcomes among hospitals such that differences in patients' length of stay and discharge practices of individual facilities may be accounted for (Borzecki, Christiansen, Chew, Loveland, & Rosen, 2010). The Centers for Medicare and Medicaid Services (CMS) currently monitors six conditions for 30-day mortality rates through its Hospital Compare website, which includes two of the selected ECSCs for this study, AMI and stroke (Medicare.gov, n.d.). A recent study concluded that there were no significant changes in all-cause 30-day mortality associated with rural hospital closures when comparing the time period from one-year prior to closure to one-year after (Joynt et al., 2015). However, previous reports have concluded that small rural hospitals have significantly higher 30-day mortality rates compared to non-small rural hospitals overall (Joynt, Harris, Orav, & Jha, 2011).

The purpose of this study is to examine whether a rural hospital closure is associated with 30-day post hospital discharge mortality for residents with selected ECSC encounters. If mortality rates increase for populations affected by rural hospital closure, rural-urban disparities in U.S. population health outcomes may expand (Hoffman & Holmes, 2017; James, 2014; Mansfield et al., 1999; Meit et al., 2015; Moy et al., 2017; Singh & Siahpush, 2014; Villapiano et al., 2017). One rural hospital closure during the past decade was the target for secondary data analyses.

Methodology

Population Studied

The study state is located in the Southeastern U.S. and did not expand its Medicaid program as a result of the Affordable Care Act (KFF, n.d.). Patient encounters from inpatient and emergency department (ED) visits for selected ECSCs in the study state were linked to vital records data to identify deaths that occurred within 30-days post hospital discharge. These encounters were analyzed by patients' county of residence according to its rural hospital status: either the hospital closed during the study period, it was open, or the county did not have one at all. Patient encounters were identified from the study population for a total period of five years: beginning two years prior to the closure, the closure year, and up to two years post-closure. The study's purpose was to examine if there was a difference in 30-day post hospital discharge mortality associated with ECSC encounters for residents of a rural county that experienced a hospital closure compared to residents of rural counties that did not.

Data Sources

Two primary data sources were utilized for this study. Patient encounter data were derived from the study state's all-payer claims database system, which is required by state statute to collect and maintain uniform billing data from acute care facilities.

State vital records data were also queried based on the patient encounters requested. Deaths occurring within 30-days of hospital discharge were linked by encounter and provided as part of the dataset. Data for calendar years 2010-2014 were obtained for analysis. Finally, U.S. Census data from the 2010 decennial Census were used to match the closure county with county comparison groups.

Definition of Study Counties

The identified hospital closure was selected using the rural hospital closures dataset provided by the Cecil G. Sheps Center for Health Services Research at The University of North Carolina at Chapel Hill (Sheps Center, 2018). Only rural hospitals permanently closed were considered. Residents of the county where the closure occurred were included in the study as the population subject to rural hospital closure. Four comparison counties were chosen to understand ongoing trends in 30-day post hospital discharge mortality that may have affected the closure county's population: two with an open hospital and two where there is no hospital (or at least has not been operating for the past thirty years) (Rosenbach & Dayhoff, 1995). Patient encounters from the comparison counties were included in the analysis.

To identify matching counties, U.S. Census data from 2010 were used to obtain demographic characteristics of population density, median household income, percent minority population, and percent elderly population (Ly et al., 2011; Rosenbach & Dayhoff, 1995). Using median linkage clustering analysis, dendrograms were created to identify pools of matches based on these four characteristics for counties in the study state as well as another U.S. state as part of a larger study conducted by the authors based on methodology developed by Rosenbach & Dayhoff (1995). Counties in the matched group that were adjacent to closure counties and/or located on the state border were excluded from being a comparison county. Population density was used to select matches closest to one another (Rosenbach & Dayhoff, 1995). The operational status of each county's local hospital was confirmed using state licensure data and/or communication with the State Office of Rural Health. Finally, one-way analysis of variance (ANOVA) tests were used to confirm that there were no significant differences in demographic characteristics between the study counties.

Table 5.1 Demographic characteristics of study counties and other counties in studied state, U.S. Census 2010

	Comparison Counties – Open Hospital	**Comparison Counties – No Hospital**	**Closure County**	**Other counties in state**
Population density (per square mile)	55.8	41.2	42.4	132.4
65yrs+ Population (%)	16.7	16.2	16.0	14.4
Minority Population (%)	43.9	44.4	64.4	42.0
Median household income ($)	33,268	38,649	32,538	38,933

Study Definitions

Inclusion criteria for the study were as follows: (1) patient encounters indicated the patient's residence was located in one of the five study counties; (2) the patient encounter was in a community hospital; and, (3) the patient encounter was associated with one of the four ECSC diagnoses chosen for the study, delineated below. Exclusion criteria for the study were patient encounters that: (1) occurred in a facility more than 100 miles from the patient's home county, since most emergencies occur within a few miles of a patient's residence (Hsia, Kanzaria, et al., 2012; J. Lee et al., 2007; NBER, 2016); (2) were the result of a transfer from a different acute care hospital or another other type of health care facility, to avoid potential confounding associated with multiple encounters for one event and/or uncertainty of interventions performed prior to or during transfer (Hashmi, et al., 2019); or, (3) were for pediatric patients ages 17 and younger, who are less likely to have an ECSC diagnosis as well as have very different care needs in general (C. Liu et al., 2014). The resulting study sample map is in Figure 5.1.

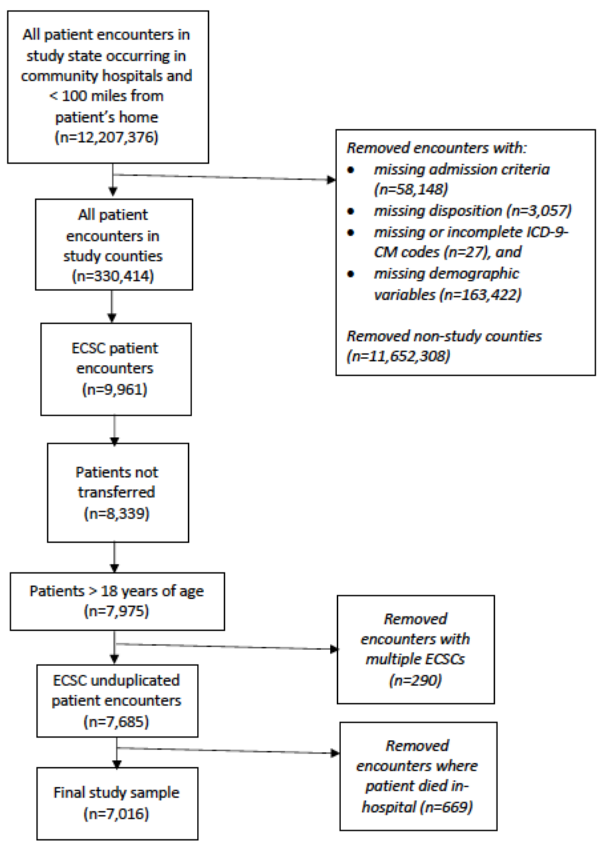

Figure 5.1 Study sample map

The most common ECSCs and the most dependent on efficient and timely access to definitive care for rural residents are acute myocardial infarction (AMI) to include ST-elevated myocardial infarction (STEMI), acute ischemic stroke, sepsis, and trauma. For this study, *International Classification of Diseases, 9th Revision* (ICD-9-CM) diagnoses codes from anywhere in the patient encounter (primary diagnosis or otherwise) were used to identify these conditions in patient encounters. Sources used to identify the appropriate ICD-9-CM codes for each condition are identified in Table 5.2.

Table 5.2 Emergency care sensitive conditions ICD-9-CM coding

ECSC	**ICD-9-CM Codes (reference)**
AMI/STEMI	**410.X** (Mehta et al., 1999)
Acute Ischemic Stroke	**430, 431, 434, 436** (McCormick et al., 2015)
Sepsis	**038.X, 995.91, 995.92, 785.52** (Wiedemann, 2007)
Trauma	**800.00 to 959.99** ***excluding 905-909, 910-924, and 930-939*** (ACS COT, 2015)

Study Design

A difference-in-difference-in-difference (DDD) quasi-experimental study design compared 30-day post hospital discharge mortality associated with ECSC patient encounters before and after the hospital closure occurred. Rates were calculated for each discharge quarter for a total five-year study period, with the rural hospital closure occurring in the tenth quarter of the total twenty quarter (60-month) study period as previously done by Kozhimannil et al. (2018). Pre-closure was defined as the nine quarters prior to the rural hospital closing; post-closure was defined as the ten quarters after the closure quarter.

The study dependent variable was 30-day post hospital discharge mortality. The independent variable was the hospital status in the patient's home county: closed, open, or none. Demographic variables were included in adjusted models; age, gender, race/ethnicity, and expected payment source were all indicators included due to their potential impact on access to care (Buchmueller et al., 2006; Joynt et al., 2015; L. Liu et al., 2001; Ly et al., 2011; Villapiano et al., 2017). Mortality risk for each patient encounter was adjusted using the Charlson comorbidity index (Charlson et al., 1987; Stagg, 2006). ED utilization per encounter was also included (Abualenain et al., 2013; Hsia, Kanzaria, et al., 2012).

Analytic Approach

Encounters with any of the four defined ECSCs were included in the analytic model except for encounters with multiple ECSCs, which were further excluded (n=290). The total study population was n=7,016. Characteristics of patient encounters in the pre-closure time period were calculated and analyzed for statistically significant differences between the study counties using chi-square (χ^2) and ANOVA tests. Bi-variate analyses comparing 30-day post hospital discharge mortality and encounter characteristics in the pre-closure time period were also performed using χ^2, ANOVA, and logistic regression tests. Mortality within 30-days post hospital discharge for each quarter was calculated by study county as a proportion of the total number of deaths per the total number of encounters for both the pre-closure and post-closure time periods. Figures representing these data omitted closure quarter rates in order to illustrate pre- and post-closure time periods clearly.

DDD logistic regression analysis was used to assess differences in 30-day post hospital discharge mortality odds between the pre-closure and post-closure time periods, with and without adjusting for demographic characteristics. All analyses were completed in Stata SE, version 15 (StataCorp, 2017). The University of South Carolina Institutional Review Board declared this study Not Human Research on November 5, 2018.

Results

There were 3,027 patient encounters associated with an ECSC in the pre-closure time period, representing an annual encounter rate of 117.02 per 10,000 population. Of these pre-closure time period encounters, 7.8% (n=236) resulted in 30-day post hospital discharge mortality. There was no significant difference in 30-day post hospital discharge mortality across the study counties in the pre-closure time period (p=0.173).

Patient demographic characteristics in the pre-closure time period were also calculated. The mean age of patients was 62.0; 51.1% were male; 52.6% were white; and 52.7% were Medicare recipients. Encounters in the closure county were significantly more likely to be associated with patients of Black race prior to closure (60.7%; p=0.000). Encounters that included ED utilization in the pre-closure time period totaled 29.0%; this number was highest in the closure county and lowest among no hospital counties (35.7% versus 18.9%; p=0.000).

Among ECSCs, 20.4% of all pre-closure time period encounters were associated with AMI diagnoses; 24.2% were associated with stroke, 39.2% sepsis, and 16.3% trauma. There were significant differences between the study counties for sepsis and trauma diagnoses, with sepsis highest in the no hospital counties (43.2%; p=0.009) and trauma highest in comparison counties with hospitals (18.0%; p=0.013).

Patient characteristics significantly associated with 30-day post hospital discharge mortality prior to closure included: age, gender, payment source, Charlson Index mean score, ED utilization during the encounter, sepsis diagnosis, and trauma diagnosis (Table 5.4). Patients who died during this period had a mean age of 73.5 and a mean Charlson Index score of 2.95. Of the entire male population, 6.8% died prior to closure compared to 8.9% of females. Among different payment sources, 10.0% of all Medicare recipients in the pre-closure time period died within 30-days post hospital discharge compared to 7.8% of Medicaid recipients, 6.0% of private-pay patients, 2.5% of self-pay patients, and 5.0% of patients with other payment sources. Of patients who utilized the ED during their encounter, 6.3% of those died within 30-days post discharge in the pre-closure time period. Ten percent of patients with a sepsis diagnosis and 0.8% with a trauma diagnoses died within 30-days post hospital discharge in the pre-closure time period.

The average 30-day post hospital discharge mortality of 8.0% in the post-closure time period was similar to that of the pre-closure time period (7.8%) and was not significantly different between study counties (p=0.080). This similarity between the pre- and post-closure time periods is also indicated in Figures 5.2 and 5.3 where the rates of 30-day post hospital discharge deaths per total encounters by study county are shown by quarter. Prior to the closure quarter, the slopes of the trend lines by study counties were not significantly different across the three conditions (data not shown). In the post-closure time period, the rate of 30-day post hospital discharge mortality for residents of the closure county appears to flatten slightly compared to the pre-closure period.

Table 5.3 Characteristics of patient encounters by closure status, pre-closure time period

	All studied visits (n=3,027)	**Visits by closure status**			
		Comparison Counties – Open Hospital (n=1,780)	**Comparison Counties – No Hospital (n=718)**	**Closure County (n=529)**	
Characteristics of visit population		*Averages*	*Averages*	*Averages*	*P value for comparison*
30-day post hospital discharge mortality (% yes)	7.8	7.6	6.8	9.6	0.173
Age (mean)	62.0	61.9	61.4	62.9	0.330
Gender (% female)	48.9	47.7	48.5	53.7	0.051
Race (% white)	52.6	56.9	52.8	37.8	**0.000**
(% black)	45.5	41.4	44.6	60.7	**0.000**
(% other)	1.9	1.7	2.7	1.5	0.249

Payment Source (% Medicare)	52.7	49.7	56.6	57.8	**0.000**
(% Medicaid)	9.7	11.5	5.6	9.3	**0.000**
(% Private)	19.7	19.4	21.5	18.3	0.346
(% Self)	13.3	14.3	11.3	12.3	0.098
(% Other)	4.6	5.1	5.2	2.3	**0.018**
Charlson Index (mean)	1.9	1.8	2.1	2.1	**0.000**
ED Utilization (% yes)	29.0	31.1	18.9	35.7	**0.000**
AMI Diagnosis (% yes)	20.4	19.9	22.0	19.5	0.439
Stroke Diagnosis (% yes)	24.2	25.1	20.8	25.5	0.051
Sepsis Diagnosis (% yes)	39.2	37.0	43.2	41.2	**0.009**
Trauma Diagnosis (% yes)	16.3	18.0	14.1	13.8	**0.013**
Bold type: significant at < p=0.05.					

Table 5.4 Patient characteristics associated with 30-day post hospital discharge mortality, pre-closure time period

Characteristics of visit population (n=3,027)	**% died**	**P value**	**ORs**	**95% CI**
30-day post hospital discharge mortality (% yes)	7.8 (n=236)	--	--	--
Age (each additional year)	--	--	**1.05**	1.039, 1.059
Gender				
Female (n=1,481)	8.9 (n=131)	**0.035**	**1.33**	1.019, 1.740
Male (n=1,546)	6.8 (n=105)	**0.035**	--	--
Race				
White (n=1,592)	8.0 (n=127)	0.696	--	--
Black (n=1,377)	7.7 (n=106)	0.853	0.96	0.735, 1.258
Other (n=58)	5.2 (n<5)	0.452	0.63	0.194, 2.040
Payment Source				
Medicare (n=1,596)	10.0 (n=160)	**0.000**	--	--
Medicaid (n=294)	7.8 (n=23)	0.986	0.76	0.483, 1.202
Private (n=596)	6.0 (n=36)	0.074	**0.58**	0.397, 0.839

Self-pay (n=401)	2.5 (n=10)	**0.000**	**0.23**	0.120, 0.439
Other (n=140)	5.0 (n=7)	0.206	0.47	0.217, 1.028
Charlson Index (mean)	--	--	**1.28**	1.212, 1.358
ED Utilization (yes versus no) (n(yes)=879)	6.3 (n=55)	**0.043**	**0.73**	0.531, 0.992
AMI Diagnosis (yes versus no) (n(yes)=616)	7.1 (n=44)	0.498	0.89	0.633, 1.249
Stroke Diagnosis (yes versus no) (n(yes)=731)	9.4 (n=69)	0.057	1.33	0.991, 1.782
Sepsis Diagnosis (yes versus no) (n(yes)=1,186)	10.0 (n=119)	**0.000**	**1.64**	1.259, 2.145
Trauma Diagnosis (yes versus no) (n(yes)=494)	0.8 (n<5)	**0.000**$^{+}$	**0.08**	0.030, 0.219

OR: Odds Ratio; CI: Confidence Interval; ED: Emergency Department; AMI: Acute Myocardial Infarction

Bold type: significant at < p=0.05; $^{+}$Fisher's exact test used.

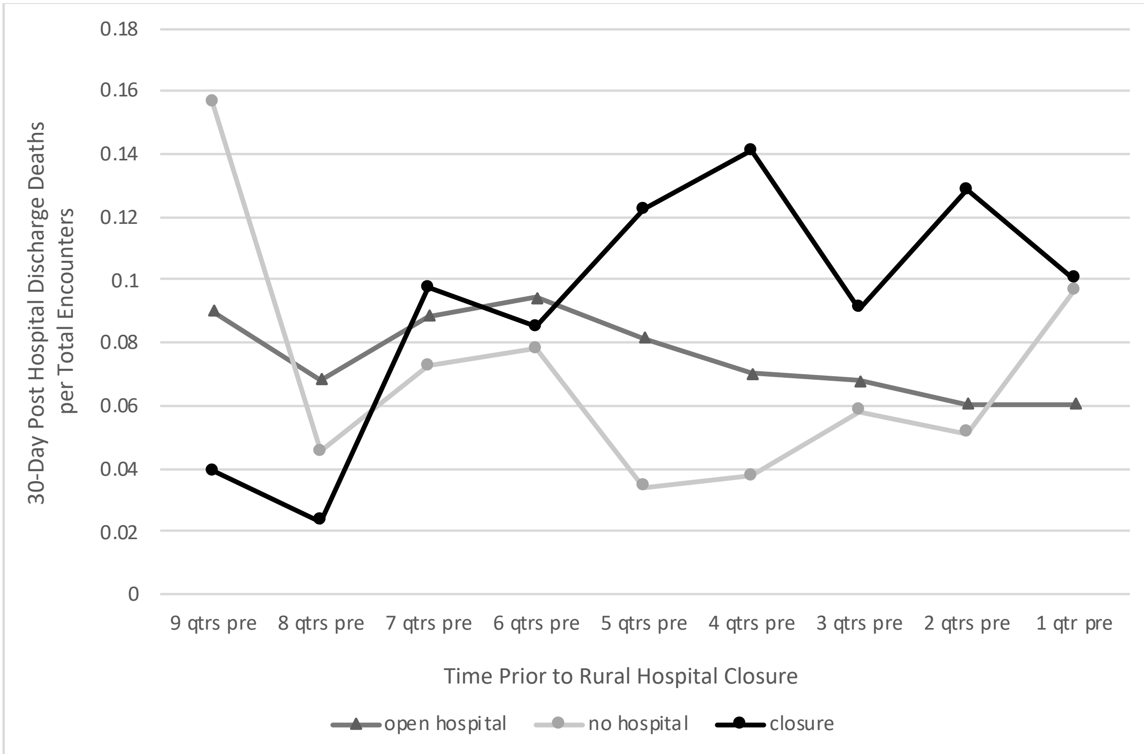

Figure 5.2 30-day post hospital discharge mortality rates, pre-closure time period

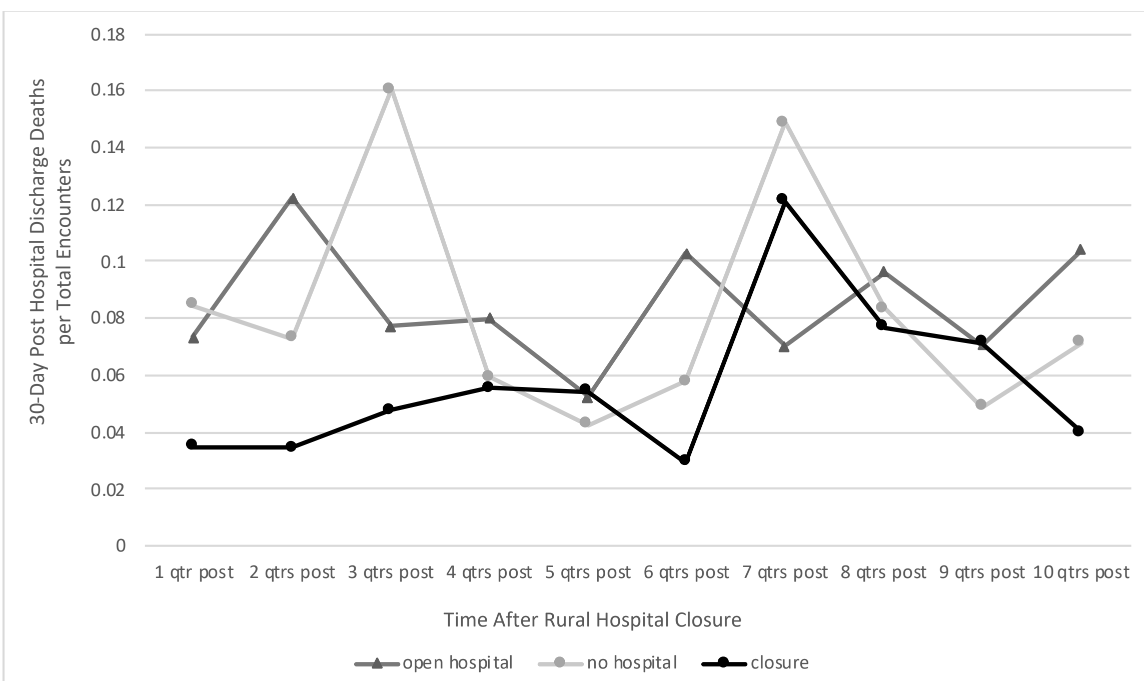

Figure 5.3 30-day post hospital discharge mortality rates, post-closure time period

These findings were further confirmed by the logistic regression analyses (Table 5.5). There was not a significant difference in 30-day post hospital discharge mortality related to ECSC encounters in the post-closure time period. For ECSC encounters from the closure county, the rate of change in 30-day post hospital discharge mortality slowed in the post-closure time period as indicated by a significant odds ratio of less than 1 for the interaction variable between time and closure status. This finding persisted in the adjusted model. Table 5.5 also includes coefficients of the interaction variables to denote the DDD values. Covariates that were significantly associated with increased 30-day post hospital discharge mortality across the entire study period included age, other payment source, mean Charlson Index score, and ED utilization.

Discussion

This study found that in one example of a rural hospital closure in a Southeastern U.S. state, 30-day post discharge mortality related to encounters for selected ECSCs was associated with hospital closure as compared to other study counties (those with and without hospitals). Specifically, the rate of 30-day post hospital discharge mortality related to ECSC encounters in the closure county appeared to decline after the closure occurred (Table 5.5). This result may be due to a number of likely scenarios. For example, this finding may represent increased access to higher quality care in the aftermath of a hospital closure, which has been reported previously (Capps et al., 2010; Fleming et al., 1995; Hsia, Kanzaria, et al., 2012; Joynt et al., 2015; Mayer et al., 1987; McLafferty, 1982; Moscovice, 1989). If the closure was anticipated with enough notice given, EMS and residents of the affected community may have had heightened awareness of the need to identify symptoms and seek services quickly, rather than delaying care inadvertently. More timely access to definitive care for an ECSC results in reduced morbidity and mortality overall (Bernstein et al., 2009; Dresden, 2013; Kocher et al., 2013; Sharp et al., 2014).

Conversely, this finding may represent decreased access in the aftermath of the closure such that residents of the county were not seeking health care services at all. Since these mortality data were provided as a result of an initial health care encounter, this study does not consider what the total death rate associated with ECSCs in the study counties was for the same time period. Overall crude mortality rates for the study counties were similar at the beginning of the study period (119.3 per 10,000 population in counties where the hospital remained open, 107.6 in counties with no hospital, and 125.7 in the county where the closure occurred) and changed very little over the course of five years (decreasing an average 1.3 overall) (Centers for Disease Control and Prevention, National Center for Health Statistics, 2018).

Developing a better understanding of how overall mortality rates may have changed as a result of a rural hospital closure is important. Knowing that the local hospital has closed may have induced apathy in local residents, causing them to not seek services when needed, as identified in a study of older adults that experienced hospital closure (Countouris et al., 2014). Similarly, learning about the closure too late, that is, not knowing until symptoms of an ECSC are present that local hospital services are no longer available, may lead to confusion and decreased access to services among county residents. All of these situations may lead to delays in care that result in increased pre-hospital and/or in-hospital mortality among residents affected by the closure (Buchmueller et al., 2006; Fleming et al., 1995).

Table 5.5 Logistic regression results, 30-day post hospital discharge mortality pre- and post-closure time periods

	Model 1 (No Covariates) (n = 7,016)			**Model 2 (With Covariates) (n = 7,016)**		
Dependent Variable: 30-Day Post Hospital Discharge Mortality	*Coefficient*	*ORs*	*95% CI*	*Coefficient*	*ORs*	*95% CI*
Post-Closure Time Period	0.011	1.16	0.925, 1.448	0.008	1.11	0.878, 1.407
County Closure Status – Closed	0.018	1.26	0.912, 1.754	0.010	1.21	0.857, 1.701
County Closure Status – No Hospital	-0.005	0.92	0.669, 1.268	-0.004	0.94	0.673, 1.310
Post-Closure Time Period * Closed Status	**-0.046**	**0.51**	0.310, 0.847	**-0.038**	**0.54**	0.320, 0.907
Post-Closure Time Period * No Hospital Status	0.002	1.03	0.671, 1.593	0.000	1.04	0.663, 1.630
Age	--	--	--	**0.003**	**1.05**	1.040, 1.057
Gender – Female	--	--	--	0.011	1.15	0.957, 1.384
Race – Black	--	--	--	-0.008	0.93	0.770, 1.122
Race – Other	--	--	--	0.011	1.08	0.501, 2.312
Payment Source – Medicaid	--	--	--	0.018	1.33	0.913, 1.948

Payment Source – Private	--	--	--	0.017	1.28	0.944, 1.744
Payment Source – Self	--	--	--	0.022	1.09	0.659, 1.814
Payment Source – Other	--	--	--	**0.074**	**3.26**	2.049, 5.198
Charlson Index	--	--	--	**0.019**	**1.24**	1.192, 1.296
ED Utilization	--	--	--	**0.052**	**2.09**	1.614, 2.714
AMI Diagnosis	--	--	--	-0.004	**4.44**	2.003, 9.832
Stroke Diagnosis	--	--	--	0.019	**6.32**	2.868, 13.931
Sepsis Diagnosis	--	--	--	**0.055**	**9.46**	4.284, 20.884
Trauma Diagnosis	--	--	--	--	--	--
	Model p value = 0.1295			Model p value = **0.0000**		

OR: Odds Ratio; CI: Confidence Interval; ED: Emergency Department; AMI: Acute Myocardial Infarction

Bold type: significant at < p=0.05.

Even if residents did seek care for an ECSC initially, post discharge complications may have required another visit to an ED and/or hospital – which had the potential for delay as a result of diminished access in the wake of a closure. Conversely, additional follow up post discharge may have been required by the admitting facility (i.e. rehabilitation services) such that patients ended up staying with family or friends closer to that facility to have access to physicians or clinics as required. Additional support post discharge from services such as those provided by home health agencies may have been more aggressively sought for patients from the affected communities due to the long commute to needed follow up services. Indeed, future studies should include these post discharge factors in determining the association between 30-day post hospital discharge mortality rates and rural hospital closures.

Overall, ECSC associated mortality rates 30-days after hospital discharge stayed the same throughout the study period observed (Table 5.5). ECSC encounters associated with 30-day post hospital discharge mortality were more likely among patients who were older and sicker, typical of rural populations (Tables 5.4 and 5.5). Significant differences in the association of gender with 30-day post hospital discharge mortality in the pre-closure time period were not sustained over the entire study period (Table 5.5).

Residents of the closure county had the highest rates of ED utilization during the pre-closure time period compared to the other counties (35.7%; p=0.000). However, ED utilization over the entire study period was significantly associated with 30-day post hospital discharge mortality (OR = 2.09) despite decreased mortality overall being an expected outcome of timely treatment in the ED (Bernstein et al., 2009; Dresden, 2013; Kocher et al., 2013; Sharp et al., 2014). It is unclear what factors may have contributed to this outcome for this study population: was *timely* treatment for ECSCs unavailable in accessible EDs? Were residents were not utilizing EDs for these conditions as suggested by the relatively low frequency of visits? Or, were a large number of these encounters due to readmissions associated with ECSCs? Further analyses are required to understand this finding.

In considering the frequency of ECSC diagnoses among these encounters, sepsis occurred most often and had the highest percentage of deaths. Stroke, AMI, and trauma encounters and deaths followed, respectively. All significantly contributed to 30-day post hospital discharge mortality over the entire study period (Table 5.5). The modest number of trauma deaths found in the study may be resultant of robust systems of trauma care developed in the 1980s (Delgado et al., 2014; Hsia et al., 2010; MacKenzie et al., 2006). By contrast, sepsis, which resulted in 10.0% of patients with this condition dying within 30-days after hospital discharge, has only recently been categorized as an illness that requires immediate intervention (V. X. Liu et al., 2017).

More specific ECSC ICD-9-CM coding and/or longer time periods (e.g. 1-year post hospital discharge mortality) may be useful for future studies. The liberal definitions applied here may have resulted in some false positives, such that there may be ECSC encounters included that are not explicitly time-sensitive. For trauma encounters, this is particularly important as there is no ability to assess or assign severity of the condition with these data. Other diagnoses may also need to be considered for rural populations affected by hospital closures. Conditions such as chronic obstructive pulmonary disease (COPD), asthma, congestive heart failure, and diabetes may result in complications that still leave patients with long commutes to definitive emergency care. Another population of concern that may be negatively impacted by closures are pediatric patients. Neither the short-term nor the long-term implications for specific patient populations experiencing hospital closure are well understood.

In summary, it is unknown whether the deceleration of the 30-day post hospital discharge mortality rate among closure county residents in the post-closure time period shown in this study represents improved access for ECSC treatment or increased pre-hospital or in-hospital mortality for residents of a county that experienced rural hospital closure. Notably, this study only represents one rural hospital closure out of the over 100 that have occurred since 2010. There is an opportunity to both study additional communities currently experiencing closure as well as to consider closures from the 1980s to understand longer-term trends in mortality.

Vulnerable populations (i.e. the elderly, the uninsured, the poor, those in need of emergency care, those lacking transportation, etc.) are at much greater risk for lack of health care access after a closure occurs (Bindman et al., 1990; Fleming et al., 1995; McKay & Coventry, 1995; Mick & Morlock, 1990; Muus et al., 1995). Additional research is needed to fully examine the explicit impact on these populations to ensure needed access to health care services is retained. Additional analyses to further elucidate associations between rural hospital closures and associated morbidity and mortality for all populations are critical as well.

Limitations

As previously stated, this study only examines one rural hospital closure out of over 100 since 2010. More data are necessary to ensure reliability of results. Further, only one state is included in the study which limits the generalizability of the study findings; however, this state was in the Southeastern U.S., which is where a majority of rural hospital closures since 2010 have occurred (Kaufman, Thomas et al., 2016).

The liberal application of the definitions of ECSCs may have also introduced bias into the data through misclassification. A more deliberate approach to identifying the most critically time-sensitive ECSCs could provide clarity around the difference a closure makes in patient outcomes. Further, identifying true patient distance and time to care for each encounter to use in analyses may increase the ability to better describe the factors important for optimal patient outcomes post-closure. As an example, patient county of residence was used as a proxy for rural hospital service areas in this study. Use of county boundaries is not an optimal substitute for hospital service area due to the geographic limitations of county borders; the area may be a too large or a too small representation of the service area depending on local utilization of the hospital facility. This limitation is an important consideration to address in future studies.

Analysis of additional health services utilization within 30-days post hospital discharge may be useful for future studies. For example, including an indicator for which encounters were readmissions within 30-days of the initial encounter, which was unavailable for this study, may have provided insight as to complications associated with ECSC encounters that ultimately resulted in mortality. Readmissions after hospital closure were reported to decrease significantly for encounters in a hospital service area affected by the closure compared to a matched non-closure area in one recent study (Joynt et al., 2015). Additional knowledge of other ED or hospital encounters occurring within the 30-day initial post hospital discharge time period would be useful additional data as well, to include looking at patient encounters originating from long-term care facilities, which were excluded from this study.

Conclusion

Here the significant association of a rural hospital closure with 30-day post hospital discharge mortality is described for patients experiencing emergency care sensitive conditions. Patients experiencing a time-sensitive emergency need emergent care to avoid poor health outcomes including morbidity associated with their condition and even death. The outcome of this study shows that the rate of 30-day post hospital discharge mortality for residents that experienced a rural hospital closure slowed following the closure of the facility. However, more work is needed to fully understand this association. Additional analyses, especially for the benefit of vulnerable populations, are needed to assure appropriate health care services are available in rural U.S. communities.

CHAPTER 6

CONCLUSION

The current trend of U.S. rural hospital closures will have profound impacts on the socio-economic and health care futures of affected communities. The full extent of these impacts, especially concerning health outcomes, are yet to be determined. This dissertation focused on determining potential associations between rural hospital closures and mortality related to encounters for emergency care sensitive conditions (ECSCs) both in-hospital and 30-days post hospital discharge. Understanding the role of rural hospital closures in changes in mortality among rural populations is critical for ensuring related disparities in mortality between rural and urban populations in the U.S. are not sustained.

Two U.S. states, from areas with a high prevalence of closures and at high risk for additional ones, were chosen for inclusion in this study. Two rural hospital closures from the past decade, one in each state, were selected to identify a study sample. Five years of hospital encounter data, from two years prior to and for two years after each closure occurred, were collected from a national dataset and a state-based all payer claims database. These encounters were selected for ECSCs occurring among adults residing in one of three types of targeted study counties: where closures occurred, and in matched comparison counties, both with and without hospitals during the study period. In-hospital or 30-day post hospital discharge (one state only) mortality were compared between the study counties.

In summary, the study results indicate that there is an association between rural hospital closures and in-hospital mortality related to ECSC encounters as outlined in Chapter 4. The average in-hospital mortality in the pre-closure time period was 8.2% versus 4.1% in the post-closure time period. For patients experiencing ECSCs that resided in closure counties, the in-hospital mortality rate declined more rapidly as compared to matched counties, both with and without hospitals, in the time period after the closure. This result did not vary by ECSC diagnosis.

Additionally, data from one state only compared 30-day post hospital discharge mortality among closure and comparison counties (Chapter 5). During the pre-closure time period, the average 30-day post hospital discharge mortality was 7.8%; in the post-closure time period the average was 8.0%. The results based on these data show that for patients experiencing ECSCs that resided in the closure county, the rate for 30-day post hospital discharge mortality slowed significantly in the time period following the closure.

Overall, the hypotheses for this work, as written, were not supported by these findings. Hypothesis 1 projected that residents of rural counties who experienced closures would have higher in-hospital mortality rates associated with ECSC encounters as compared to residents of rural counties that did not experience a closure. This was not supported by the study. Hypothesis 2 suggested that this finding would vary by ECSC diagnosis and was also not supported. Finally, Hypothesis 3 suggested that rural residents that experienced a closure would have higher 30-day post hospital discharge mortality rates associated with ECSCs as compared to rural residents of counties that did not experience a closure. This hypothesis also was not supported by the study.

Although these hypotheses were not supported by the study analyses, this work is a necessary step in determining health outcomes associated with rural hospital closures. This study demonstrated outcomes associated with mortality after utilization of health care services for two rural hospital closures in two states. However, two rural hospital closures out of over 100 in the past decade does not provide enough data for a robust study of this issue. Increased distances and travel times to receive health care services are known to delay care and reduce utilization, especially among vulnerable populations. Research is needed to assess health outcomes, especially mortality risk, among all residents of rural communities that experience a hospital closure to include those who may not seek care at all. This is a critical knowledge gap that should be addressed in support of mitigating ongoing health disparities between rural and urban U.S. populations.

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APPENDIX A: SENSITIVITY ANALYSIS

An additional analysis was performed replicating the methodology and study population used for research question 1, substituting for ECSCs other conditions that do not require timely interventions but that may still have expected in-hospital mortality. Congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and diabetes were selected based on previous research (Buchmueller et al., 2006); the ICD-9-CM and ICD-10-CM diagnoses codes used for this analysis are in Table A.1.

Table A.1 Selected non time-sensitive conditions ICD-9-CM and ICD-10-CM coding

Non Time-Sensitive Condition	**ICD-9-CM Codes (reference)**	**ICD-10-CM Codes (reference)**
CHF	**428.0, 428.1, 428.2X, 428.3X, 428.4X, 428.9** (CMS.gov, n.d.)	**I50.1, I50.2X, I50.3X, I50.4X, I50.9** (CMS.gov, n.d.)
COPD	**491.0, 491.1, 491.2X, 491.8, 491.9, 492.0, 492.8, 494.0, 494.1, 496, 506.4** (Boehringer Ingelheim Pharmaceuticals (BIP), 2011)	**J40, J41.X, J42, J43.X, J44.X, J47.X** (BIP, 2011)
Diabetes	**250.X** (Amaize & Mistry, 2016)	**E10, E11** (Dugan & Shubrook, 2017)

The analysis revealed that 1.5% of these encounters for non time-sensitive conditions resulted in in-hospital mortality during the pre-closure time period. There was an overall significant decline in in-hospital mortality in the post-closure time period, similar to the result found for ECSCs outlined in Chapter 4. In the unadjusted model, the rate of change was significantly greater for residents of counties with no hospital. In the adjusted model, the rate of change was significantly greater for residents of closure counties (data not shown). Figures A.1 and A.2 below depict the in-hospital mortality rates in the pre-closure and post-closure time periods for encounters associated with ECSCs (as also shown in Chapter 4) and selected non time-sensitive conditions.

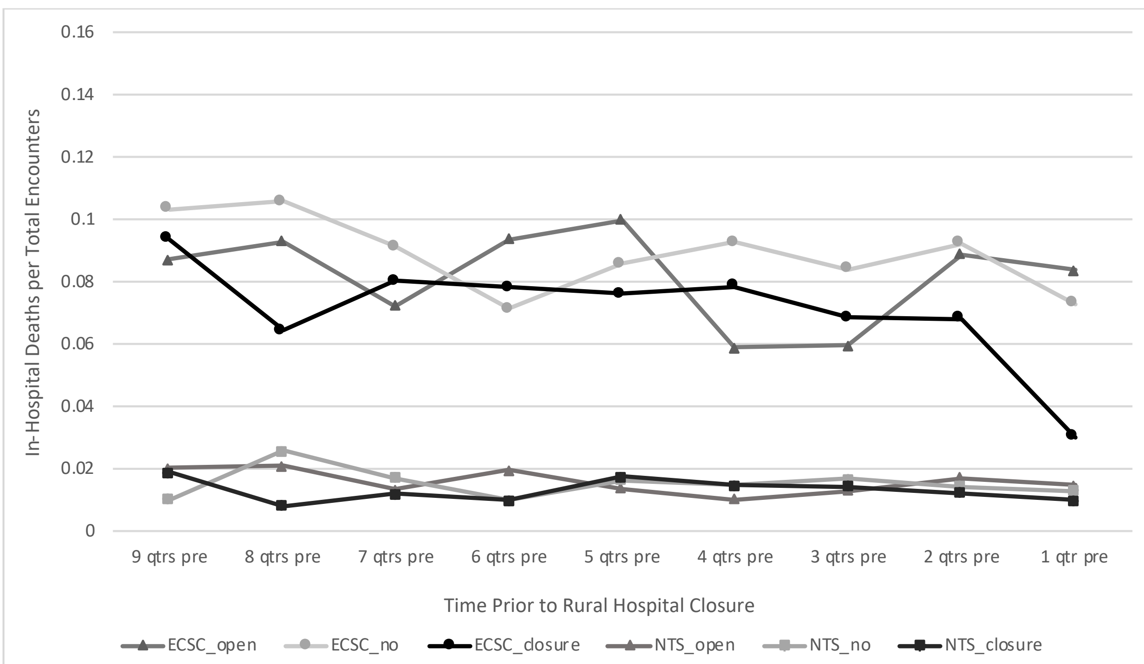

Figure A.1 ECSC and non time-sensitive (NTS) condition in-hospital mortality rates, pre-closure time period

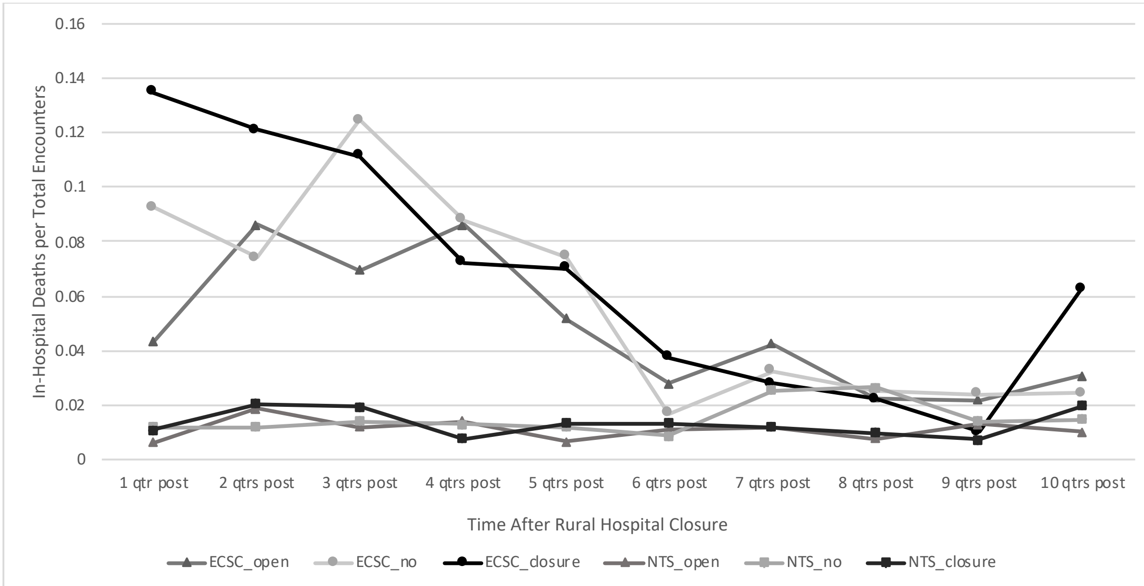

Figure A.2 ECSC and non time-sensitive (NTS) condition in-hospital mortality rates, post-closure time period