MICHIGAN ROSS

Who Loses Out?

Evaluating the Association Between County Vulnerability and Closures of U.S. Hospitals, Emergency Departments, and Obstetrics Departments

by

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Abstract

Over the past several years, hospital, emergency department, and obstetrics department closures have greatly impacted the hospital industry across the U.S. While current research documents the reasons why closures occur and how they may impact health care access and outcomes, there is a current gap in recent literature about the characteristics of the surrounding communities where closures occur. This thesis aims to answer the following question: What is the association between county demographics and closures of U.S. hospitals, emergency departments, and obstetrics departments? The analysis spans the years 2010-2019 and uses hospital data from the American Hospital Association's Annual Surveys, county demographic data from the U.S. Census Bureau's 5-year American Community Survey estimates, and county vulnerability data from the CDC/ATSDR 2019 Social Vulnerability Index. Results show substantial socioeconomic and racial disparities in counties that experienced closures of hospitals and emergency departments during this study's 10-year time period, with fewer disparities in counties where obstetrics department closures occur. After controlling for socioeconomic factors, Hispanic race and Black race were significant in predicting the likelihood of a county experiencing a hospital or emergency department closure (positive association). Black race was also significantly associated with the likelihood of an obstetrics department closure (positive association). Ultimately, the findings from this thesis suggest that poorer communities and communities of color are disproportionately impacted by closures, and unless trends change or interventions are implemented, these communities may continue to face greater barriers to health care access in the future, as closures rise.

Contents

Introduction

The U.S. health care industry is a market that has experienced and continues to experience major restructuring from changes in technology, legislation, population trends, and more. These changes influence many different areas of health care, from health care delivery to costs of medical care to workforces. One major area that has been impacted by such changes is the hospital landscape. Hospitals are the centerpiece of the American health care system, as they employ millions of Americans, generate trillions of dollars in economic activity, and, most importantly, serve as the major avenue through which patients across the country access medical treatment (Samuelson, 2017). Over the past few decades, U.S. hospitals have undergone fluctuations in number, as rates of hospital closures and openings changed. Today, the rate of hospital closures is once again on the rise, and the history behind why the hospital market is experiencing such changes is discussed in this section.

History of U.S. Hospital Closures

In the 1970s and 1980s, a wave of hospital closures across the U.S. ensued, with nearly 1,000 hospitals closing in just two decades (Topping, 1991). This trend came at an unexpected time, since just years prior (in 1965), Medicare and Medicaid were passed (Dallek, 1983). In theory, having insurance programs that cover millions of poor and elderly patients should have significantly improved the financial viability of smaller hospitals that relied heavily on payer reimbursement as a major revenue source and hospitals that served low-income populations. However, in the years following the passage of Medicaid and Medicare, many states enacted Medicaid cuts, which reduced the number of eligible individuals in the program and increased the burden of caring for the poor on hospitals (Dallek, 1983).

In addition, payer reimbursement was not the only factor impacting closures in the 1970s and 1980s. A number of external and internal factors played a role. External factors included high physician-to-population ratios (leading to high competition), the geographical region of the hospitals, and regulatory review and compliance (Topping, 1991). Internal factors were fairly interdependent and consisted of demand for hospital services (with lower demand leading to greater excess hospital bed capacity and lower occupancy rates), managerial and financial issues, hospital size, and hospital ownership (Topping, 1991). From these factors, financial issues relating to payer reimbursement and demand for hospital services became actionable objectives for policymakers, as these factors disproportionately impacted the closure of rural hospitals. In addition, towards the late 1980s, more rural hospitals than urban hospitals were closing. The combination of financial issues and rural hospital closures led to important policy changes for hospitals in the 1990s.

Critical Access Hospital Designation

In 1997, the Balanced Budget Act was passed. Among its many provisions included the creation of the Critical Access Hospital (CAH) designation, which still exists today (Rural Health Information Hub, 2021). The goal of this designation was to reduce the financial burden of rural hospitals that faced challenges in remaining open due to the limited patient populations served by these hospitals, due to their location in sparsely populated areas. CAHs must meet several conditions, including having a 24/7 emergency department and having 25 or less acute care inpatient beds (Rural Health Information Hub, 2021). In return, these hospitals are reimbursed over cost by Medicare and in some states, by Medicaid as well. This designation helped slow the pace of rural hospital closures nationwide, until the 2008-2009 recession (“Rural Hospital Closures,” n.d.).

Changing Trends–Economic Recession and the Affordable Care Act

With the recession of 2008-2009, the hospital market was greatly affected. Hospital reimbursement, inpatient admissions, charitable donations, the ability to obtain bonds, and overall hospital margins all fell as a result of the recession (Sussman et al., 2010). As hospital finances suffered, so did access to care for Americans. Hospitals of all types closed in the aftermath of the recession, and notably, the previously stagnant trend of rural hospital closures rebounded (Bazzoli et al., 2014; "Rural Hospital Closures," n.d.).

Around the same time as the effects of the recession on hospital closures were unfolding, the Affordable Care Act (ACA) was passed. The passage of the ACA introduced federal subsidies intended to expand the scope of which Americans were eligible for Medicaid—specifically, eligibility of childless adults (Lindrooth et al., 2018). Not all states chose to adopt this provision and expand Medicaid, but despite this, the ACA narrowed the gap in health insurance coverage across socioeconomic groups in all states (Griffith et al., 2017). Hospital in states that expanded Medicaid did benefit more though. Financial performance of hospitals in these states improved, with hospitals experiencing lower likelihoods of closure (Lindrooth et al., 2018). The improvement in financial performance and reduction in closures was starker in rural areas than urban areas. Today, rural hospitals in states that expanded Medicaid are 62% less likely to close than hospitals in states that did not expand Medicaid (The Chartis Group, 2020). Hospitals in states that expanded Medicaid spend less on uncompensated care than hospitals in states that did not expand Medicaid, implying that the relationship between hospital financial viability and risk of closure is mediated by the proportion of uninsured patients a hospital serves (2018).

Hospital Department Closures

While it is true that the rates of hospital closures are still high today, other forms of closures with important implications for health care access have also been on the rise. The hospital departments that show significant recent trends in closures are emergency departments and obstetrics departments. The number of emergency departments nationally has declined in recent years, with 27% of hospital-based emergency departments closing between 1990-2009 (Hsia et al., 2011). Emergency departments are unique in that they are required by federal law (the Emergency Medical Treatment and Labor Act) to care for anyone who comes in, regardless of their ability to pay (*EMTALA Fact Sheet*, n.d.). This means that emergency departments end up serving a disproportionate number of uninsured patients (Wilson & Cutler, 2014). Obstetrics department closures have also been increasing, especially in rural areas. Between 2004-2014, 179 rural counties lost obstetrics services at their hospitals (CMS, 2019). Pregnant women have many medical needs during and after pregnancy, and the closure of obstetrics departments presents an important issue that may pose a barrier to women receiving the appropriate medical treatment to have healthy pregnancies.

Problem Statement and Justification

Problem Statement

The purpose of this thesis is to document national trends in hospital, emergency department, and obstetrics department closures between 2010-2019. This thesis will also analyze the association between county vulnerability and the occurrence of hospital, emergency department, and obstetrics department closures. My hypothesis is that closures in recent years have been more likely to occur in counties with greater levels of vulnerability (ex: higher proportion of individuals who are uninsured, low-income, etc.). I anticipate that these findings will be consistent with older literature documenting demographic trends and will support current literature about health care access.

Problem Justification

Despite the breadth of research about hospital, emergency department, and obstetrics department closures, there is very little current research about the characteristics of the communities in which closures occur. As will be outlined in the Literature Review, the more recent literature focuses on rural hospitals and obstetrics department closures, with little attention given to the overall characteristics of communities impacted by any type of closure, regardless of rural nature. Rural areas are only one subset of the U.S. impacted by closures, so it is critical to understand how other areas are impacted by closures as well. In addition to the trends discussed in the Introduction, the COVID-19 pandemic has accelerated the rate of hospital closures, with 19 hospitals closing in 2020 (and dozens more declaring bankruptcy) (Christensen, 2021). Thus, the imperative for studying disparities in the impact of closures is even more relevant now.

While it is likely that the results of this study will find some disparities in the characteristics of the counties impacted by closures, what those exact disparities will be is

unclear. The design of this thesis also allows for direct comparisons to be made among hospital, emergency department, and obstetrics department closures. This allows for important questions to be answered, such as: “Are vulnerable counties less, equally, or more likely to experience closures of hospitals compared to closures of obstetrics departments?” “Have counties that experienced closure of a hospital become more vulnerable over time?” These are just a few of the questions that may be answered through this thesis.

Importantly, having recent, data-backed research on this topic can yield valuable insights about deeper disparities in health care access in the U.S. and which communities may suffer as hospital and hospital department closures continue in the coming years.

Literature Review

Within the intersection of health economics and public health, there is a breadth of research about access to health care. In the context of hospital closures, much of the literature narrows down to focus on why hospitals and hospital departments close, as well as the impact of closures on communities and health outcomes. The following review analyzes the factors that influence closures, the impact of closures, and current research about the role of community demographics in relation to closures.

Factors Influencing Closures

First and foremost, it is important to understand why hospitals close. The characteristics of hospital closures over the past two decades resemble the characteristics of hospital closures between 1970-1990. The scholarly literature varies about the nuances, but most papers agree on the presence of a few factors as increasing the likelihood of closures. Hospitals that are smaller, have lower occupancy rates, have poor operating margins, and generate high salary and benefit expenses are more likely to close than other hospitals (Daugherty & Escobedo, 2013; O'Hanlon et al., 2019; Rosenbach & Dayhoff, 1995). Other factors that increase the risk of closure include fewer admissions, fewer hospital services offered, and fewer/smaller facilities (Whiteis, 1992). For these reasons, rural hospitals tend to face be at greater risk of closure—not because these hospitals are unique in any one way, but they do tend to experience more of the risk factors for closure, due to their location in sparsely populated regions (Daugherty & Escobedo, 2013).

The closures of emergency departments and obstetrics departments are often studied separately from hospitals, as hospitals may choose to close these departments to prevent the overall hospital from closing. As discussed in the Introduction, emergency departments tend to serve a disproportionately higher number of marginalized patients compared to other hospital

departments, so it is important to understand when and where emergency services are being discontinued. Hsia cites the following reasons as predictors for emergency department closures: presence in a competitive environment, identification as a safety-net hospital, low profit margin, and ownership by a for-profit entity (2011). Most emergency department closures occur in hospitals that are already associated with larger health systems (Venkatesh et al., 2021). Like hospitals, emergency department closures have also been influenced by the ACA. Emergency departments in states that have expanded Medicaid are more likely to close than those in non-expansion states (Friedman et al., 2016; Hsia & Shen, 2019). This is consistent with the fact that emergency departments serve many poor and uninsured patients. Thus, having wider coverage under Medicaid aids emergency departments by reducing the financial burden of treating marginalized patients.

The research on obstetrics departments shows similar findings to the literature on emergency departments. In many cases, hospitals close their obstetrics departments due to low child delivery volumes, financial issues associated with treating Medicaid patients, and staffing issues (Zhao, 2007). Obstetrics departments are also more likely to close in private rural hospitals, as well as in rural hospitals that merge (Henke et al., 2021; Hung et al., 2016). Considering that rural hospitals generally have higher facility costs (Xu et al., 2015), this observation is reasonable. When considering closures of obstetrics departments, it is important to recognize that obstetrics departments are incredibly expensive for hospitals to maintain. Annual estimates of the total facility costs of maternity care in the U.S. reached $15.1 billion in 2011, with higher costs at government, nonprofit, and rural hospitals (Xu et al., 2015). The sheer expense of managing an obstetrics department is a primary reason why hospitals close these departments.

Impact of Closures

In many cases, closures play a role in reducing access to medical care, which in turn can have direct implications on health outcomes. Several studies point to worse health outcomes, such as worse mental/physical health and increased risk of mortality from heart attacks/unintentional injuries, for patients in communities where hospitals closed (Bindman et al., 1990; Buchmueller et al., 2006). Emergency department closures have been found to lead to higher mortality and readmission rates, as distance to nearby emergency departments increases (Hsia & Shen, 2019; Shen & Hsia, 2016). Similarly, obstetrics department closures impact health outcomes. In a comparative analysis of hospitals that retained and lost their obstetrics units, Kozhimannil found that a loss of obstetrics services was associated with "increased out-of-hospital and preterm births and births in hospitals without obstetrics units in the following year" (2018). This suggests that closure of obstetrics departments is correlated with direct impacts on the health of infants and potentially even mothers.

Closures in Relation to Community Demographics

Some studies have looked at community demographics where closures occur─Daugherty and Escobedo find that hospitals in areas with rising unemployment rates are more likely to close (2013). In general, however, the demographics of communities where hospital closures occur has not been well-documented recently. Several papers in the 1980s and 1990s map out a few relationships. In a study of New York City hospital closures in the 1970s-1980s, Schatzkin found predictors of hospital closures to include "the proportion of inpatients who were nonwhite...[and the] racial composition of [the] surrounding neighborhood" (1984). Two more studies build on Schatzkin's findings. A different study of New York City hospitals found that hospitals in minority, low-income neighborhoods are more prone to close (McLafferty, 1982). A final study

conducted on urban hospitals across the nation discovered a positive association between the proportion of black residents and hospital closures (Whiteis, 1992).

Notably, these papers are dated and/or limited in geographic scope, so this thesis complements existing literature by analyzing recent trends in closures for the entire United States and conducting a side-by-side comparison of hospital, emergency department, and obstetrics department closures.

Theoretical Framework

While several conceptual frameworks could be used as a lens through which hospital and hospital department closures can be analyzed, most of the assumptions within this thesis can be understood from the perspective of a profit-maximizing firm. Under this framework, hospitals and health systems are the firms. The general idea is that hospitals attempt to maximize profits, and they make decisions regarding which services to maintain or end (or whether to close a hospital completely) depending on profitability. Certain services are inherently unprofitable (ex: obstetrics services), so those departments may be the first to be eliminated when hospitals make decisions to raise profitability by cutting costs (Horwitz & Nichols, 2022).

The argument could be made that profit maximization depends on how a hospital is organized: specifically, if the hospital is for-profit vs nonprofit. While it is true that there are inherent differences in hospital structure that influence the financial decisions hospitals can make, the reality is that the behavior of for-profit and nonprofit hospitals does not differ greatly, as it relates to offering services based on profitability. For-profit hospitals are less likely than nonprofit hospitals to offer unprofitable services to begin with, and they are the most likely of any hospital type to end unprofitable hospital services (Horwitz & Nichols, 2022). However, nonprofit hospitals do still end services that are unprofitable, if profitability decreases significantly (Horwitz, 2005). Thus, we may expect that in theory, nonprofit hospitals are less likely to close and less likely to close departments compared to for-profit hospitals, but if losses are too large, then those hospitals will act like for-profit hospitals. Therefore, the framework of hospitals acting as profit-maximizers can apply to hospitals, regardless of ownership type, and this is the framework by which closures are considered in this thesis.

Methodology

A descriptive analysis, univariate regressions, and multivariate regressions were conducted to assess national closure trends and the relationship between county vulnerability and closures of hospitals, emergency departments, and obstetrics departments.

Hospital and Closure Data

Hospital characteristics and service data were used from the American Hospital Association (AHA) Annual Surveys, for the years 2010-2019. Data captured in these surveys included geographic location of the hospital, service line offerings, number of beds and admissions, and other key hospital characteristics. The sample included hospitals in all 50 states that filled out the survey each year during the study's time frame. Hospitals in U.S. territories and freely associated states were excluded from the analysis. Analysis of hospital closures was limited to short-term acute care hospitals, which are the primary way routine care is delivered. Psychiatric, long-term acute care, and specialty hospitals were excluded.

A hospital was considered to have closed if a hospital ID was present in the data but disappeared prior to 2019. An emergency department was considered to have closed if a hospital listed as having visits to its emergency department started reporting 0 emergency department visits. An obstetrics department was considered to have closed if a hospital listed as having 1) obstetrics services or 2) obstetrics beds and 3) births at the hospital started reporting no services or no beds and no births. All identified closures of hospitals, emergency departments, and obstetrics departments were validated through Internet searches to confirm actual closure.

Demographic Data

Two sources of county-level demographic data were used to identify trends: the CDC/ATSDR 2019 Social Vulnerability Index (SVI), and the U.S. Census Bureau's 5-year

American Community Survey (ACS) for 2010-2014. The SVI was used as a proxy for the level of 'social vulnerability' in a county and is based on U.S. Census data. It measures five themes of vulnerability: overall vulnerability, socioeconomic status, household composition/disability, minority status/language, and housing type/transportation (**Figure 1**). The values of the SVI range between 0-1, with a higher value corresponding to a higher level of vulnerability or disadvantage. The ACS was used to provide a more comprehensive breakdown of county demographics, and its information is more recent than that of the Decennial Census. The following data was collected from the ACS, for every county in the U.S.: percent unemployed for population 16 years and over in the labor force; percent of households with food stamps/SNAP benefits; percent of families and people whose income is below the poverty level; percent uninsured among the civilian noninstitutionalized population; percent Black race; percent Hispanic race; and percent elderly.

Empirical Analysis

The empirical analysis began with a descriptive analysis conducted by (1) analyzing changes over time of quartiles that counties fall into based on vulnerability levels and (2) comparing the overall demographics of counties that experienced closures to counties that did not.

Quartiles based on the SVI were calculated to represent the ranges of SVI values between 0-0.25, 0.26-0.5, 0.51-0.75, and 0.76-1.0 (with the upper quartiles representing greater county vulnerability). These quartiles were used to assess the percentage of counties with at least 1 hospital that fell in each quartile, as well as the percentage of counties that experienced closures that fell in each quartile, in 2010 and again in 2019. Separate quartiles were generated for each of the SVI themes, and this analysis was repeated for counties with emergency

departments/emergency department closures, as well as obstetrics departments/obstetrics department closures.

Using the five SVI themes and the seven demographic measures from the ACS, a separate descriptive analysis was conducted of counties that had no hospital closures, had hospital closures, and had no hospitals during the study period. For each of the three categories of counties, the mean and median of all vulnerability measures were taken. Both unweighted and weighted means and medians were recorded, with weighted means and medians based on the county population size (larger counties held greater weight in calculating the mean and median). ANOVA tests were run on the mean values of each vulnerability measure, comparing the significance of the differences in demographics among the three categories of counties. This descriptive analysis (along with ANOVA tests) was then repeated for emergency departments and obstetrics departments.

For the regression, both univariate and multivariate logistic regressions were conducted. The regressions were intended to assess the impact of various county-level demographics on the likelihood of closure. The dependent variable in these models was coded as a binary outcome to represent counties that did or did not experience a closure during the study period. The independent variables were the following six demographic variables sourced from the ACS, chosen due to their limited multicollinearity (variance inflation factor below 3): poverty, unemployment, uninsurance, Black race, Hispanic race, and elderly. Univariate regression analyses were run for each independent variable for each type of closure (hospital, emergency department, and obstetrics department). Three separate multivariate models were then generated, for each type of closure (**Figure 2**). The logistic model was chosen over other models due to its

ability to better map the relationship between several independent variables and a binary dependent variable. These models were constructed using the glm package in R.

Results

Between 2010-2019, there were 236 closures of short-term acute care hospitals, 203 closures of emergency departments, and 213 closures of obstetrics departments nationally (**Figure 3**). 38% of hospital closures, 43% of emergency department closures, and 49% of obstetrics department closures occurred in rural areas (**Figure 3**).

SVI Quartile Analysis - Closures

Overall, the largest differences among counties with respect to closures over time were observed in the first and fourth quartiles of vulnerability, which will be discussed in this section (see Tables 1-3 for additional detail on other quartiles). For hospital closures, counties in Q4 (most vulnerable) experienced a substantially greater net loss of hospitals than counties in Q1 (least vulnerable), based on all SVI measures besides minority status/language (**Column III, Table 1**). For example, counties with the lowest socioeconomic status experienced a 4.35% loss in hospitals over the study period, compared to a 0.13% increase in hospitals for counties with the highest socioeconomic status (**Figure 4**). In addition, counties that experienced at least 1 hospital closure over the study period were much more likely to be concentrated in Q4 than Q1, for all SVI measures (**Column IV, Table 1**). This difference was most substantial between Q1 and Q4 on the basis of minority status/language, in which only 2.53% of counties in Q1 experienced closures, whereas 11.76% of counties in Q4 had hospital closures (**Minority Status/Language, Column IV, Table 1**).

For emergency department closures, counties in Q4 experienced a greater net loss of emergency departments than counties in Q1 for all SVI measures besides minority status/language, with very similar trends over time as hospitals (**Column III, Table 2; Figure 5**). Counties with at least 1 emergency department closure were also more likely to be found in

Q4 than Q1, for all SVI measures (**Column IV, Table 2**). The largest difference was present for overall vulnerability, where 1.14% of counties in Q1 had an emergency department closure, compared to 9.34% of counties in Q4 (**Overall Vulnerability, Column IV, Table 2**).

Obstetrics department closures followed somewhat different trends than hospital and emergency department closures. For all vulnerability metrics, counties in both Q1 and Q4 experienced a net loss of obstetrics departments over time (**Column III, Table 3**). However, counties in Q4 only experienced a greater net loss of obstetrics departments than Q1 based on household composition/disability (**Figure 6**). The direct analysis of closures reflected slightly more variation in where closures were concentrated. For overall vulnerability, minority status/language, and housing type/transportation, counties that experienced closures were more likely to be in Q4 than Q1 (**Column IV, Table 3)**. However, for socioeconomic status and household composition/disability, counties with closures were actually more concentrated in Q1 than Q4. For example, 7.39% of counties in Q1 of household composition/disability experienced an obstetrics department closure, compared to 4.73% of counties in Q4.

SVI Quartile Analysis – Other Measures of Health Care Access

Changes over time in several other measures of health care access were also analyzed: beds/capita per 1,000; emergency departments/capita per 10,000; and obstetrics department/capita per 10,000.

For all SVI measures besides minority status/language, counties in Q4 experienced a greater decline in beds/capita than counties in Q1 between 2010-2019 (**Column III, Table 4**). For some measures, such as household composition/disability, counties in Q4 experienced losses over 34% greater than counties in Q1. Counties in Q4 also experienced greater declines in emergency departments/capita than counties in Q1, for all SVI measures besides minority

status/language (**Column III, Table 5**). In contrast, declines of obstetrics departments/capita were only higher for counties in Q4 than Q1 for minority status/language and housing type/transportation (**Column III, Table 6**). However, even these differences were minimal, as they did not exceed a 1% difference between Q1 and Q4.

Comparative Analysis of Demographics

A comparative analysis was conducted for the five SVI themes and the seven ACS demographic characteristics for each of the following groups: counties without hospital closures, counties with hospital closures, and counties without any hospitals during the study period. Both weighted and unweighted means and medians were calculated, in addition to ANOVA tests for significance. These same analyses were repeated for emergency departments and obstetrics departments.

In both the weighted and unweighted analyses of the mean and median, counties with hospital closures were more vulnerable than counties without closures and counties without hospitals for all SVI measures besides household composition/disability (**Table 7**). Differences in the means of minority status/language, as well as housing type/transportation, were significant after ANOVA tests were conducted. Of note, after the weighted analysis was conducted, the mean and median values for minority status/language for counties without and counties with closures rose by about 40% (**Table 7**). The weighted mean for counties with closures became 0.89, and the weighted median became 0.96─irrespective of how these values compare to other groups of counties, they are remarkably high and should be highlighted, given that the maximum SVI value is 1.0.

Upon analysis of the seven ACS measures for hospitals, counties with hospital closures had higher mean and median values for all measures besides percent elderly, in the weighted and

unweighted analyses (**Table 7**). All differences in means across groups of counties were significant. The previously identified high SVI values of minority status/language were reflected in the mean and median values for Black and Hispanic race. The weighted mean for Black race was 16.34% for counties with closures, compared to 11.36% for counties without closures and 11.19% for counties without hospitals (**Table 7**). The weighted mean for Hispanic race was 27.66% for counties with closures, compared to 14.64% for counties without closures and 11.02% for counties without hospitals (**Table 7**). Median values were very similar in magnitude.

Counties with emergency department closures were more vulnerable than counties without closures and counties without emergency departments for the SVI measures of overall vulnerability, minority status/language, and housing type/transportation in the weighted and unweighted analyses of the mean and median (**Table 8**). Differences in the means of household composition/disability, minority status/language, and housing type/transportation were significant after ANOVA tests were conducted. Similar to hospital closures, the weighted mean and median SVI values for minority status/language were quite high (0.84 and 0.95 respectively) (**Table 8**).

Counties with emergency department closures were also observed to have higher rates of unemployment, uninsurance, Black race, and Hispanic race, in both the weighted and unweighted analyses of the mean and median (**Table 8**). Differences in means were significant for all ACS measures. The largest differences in mean and median values existed for comparisons of Black and Hispanic race. For example, the weighted mean percentage of Black individuals in counties with closures was 17.11%, compared to 11.78% in counties without closures and 10.11% in counties without emergency departments (**Table 8**).

Counties with obstetrics department closures were more vulnerable than counties without closures and counties without obstetrics departments for the SVI measures of overall vulnerability, minority status/language, and housing type/transportation in the weighted and unweighted analyses of the mean and median (**Table 9**). Differences in the means of household composition/disability, minority status/language, and housing type/transportation were significant after ANOVA tests were conducted. Once again, the weighted mean and median SVI values for minority status/language were high (0.84 and 0.92) (**Table 9**).

Counties with obstetrics department closures were only observed to have higher measures of Black race for both the mean and median weighted and unweighted analyses, though Hispanic race, unemployment, and uninsurance were all higher in the mean and median weighted analyses than these measures for counties without closures and counties without obstetrics departments (**Table 9**). Differences in means were significant for all ACS measures.

Logistic Regression

In the univariate analysis for hospital closures, all six independent variables were significantly associated with the likelihood of closure at the highest level of significance (**Columns I-VI, Table 10**). The percentage of elderly in a county was negatively associated with the likelihood of closure, while all other variables showed positive associations. In the multivariate regression, Hispanic race, Black race, and elderly were significantly associated with the likelihood of closure, after controlling for poverty, unemployment, and uninsurance (**Column VII, Table 10**). Hispanic and Black race were significant at the highest levels and were positively associated with the likelihood of closures, while the percentage of elderly was negatively associated with the likelihood of closure. The magnitude of these variables was notable. For example, going from 0% to 100% Black residents in a county increased the

probability of hospital closure by 16.9%, while going from 0% to 100% in the percentage of elderly residents in a county reduced the probability of a closure by 17.1%.

In the univariate analysis for emergency department closures, all six independent variables were significantly associated with the likelihood of closure at the highest level of significance, with the exception of a lower significance level for Hispanic race and elderly (**Columns I-VI, Table 11**). The percentage of elderly was negatively associated with the likelihood of closure, while all other variables were positively associated with the likelihood of closure. In the multivariate analysis, only Hispanic and Black race were significantly associated with the likelihood of closure, after controlling for poverty, unemployment, uninsurance, and elderly (**Column VII, Table 11**). The magnitude of these relationships for emergency department closures was smaller than that for hospital closures. For example, a 0% to 100% change in the percent of Black residents increased the probability of closure by 13.2%, while a 100% increase in the percentage of elderly residents reduced the probability of closure by 6.6%.

In the univariate analysis for obstetrics department closures, only uninsurance and elderly were significantly associated with the probability of an obstetrics department closure, at the lowest level of significance (**Columns I-VI, Table 12**). Both variables showed a negative relationship with the likelihood of closure. In the multivariate analysis, Black race and uninsurance were significantly associated with the likelihood of closure, after controlling for poverty, unemployment, Hispanic race, and elderly (**Column VII, Table 12**). Black race had a positive relationship, while the rate of uninsurance had a negative relationship. A 100% increase in the percent of Black residents in a county increased the probability of closure by 6%, while a 100% increase in the uninsurance rate decreased the probability of closure by 21.7%.

To further contextualize the relative magnitudes of the impact of demographic variables on the likelihood of hospital, emergency department, and obstetrics department closures, a quartile analysis was conducted by testing the three multivariate models. The values for counties that fell in the 25th and 75th percentiles of the six independent variables were used to predict the likelihood of closures (**Figure 7**). The 25th percentile of counties had a 4.35% likelihood of experiencing a hospital closure, while the 75th percentile had a 6.36% likelihood of closure. For emergency departments, the 25th percentile had a 3.46% likelihood of experiencing a closure, compared to 6.13% for the 75th percentile. Obstetrics department closures did not follow the same trends of the 75th percentile having a higher likelihood of experiencing closures. The 25th percentile had a 6.97% likelihood of obstetrics department closure, compared to 5.21% for the 75th percentile. These results are consistent with the analysis of the individual regression models, where the magnitude of the effect of demographics on the likelihood of closure is higher for hospitals and emergency departments compared to obstetrics departments.

Discussion

The results of the various analyses conducted indicate that over the past decade, counties that experienced closures of hospitals and emergency departments were more substantially more vulnerable on a variety of metrics than counties that did not experience closures. However, counties that had obstetrics departments closures did not show differences in vulnerability that were as stark (though disparities in vulnerability were still present in counties with closures). Importantly, more vulnerable counties also experienced a greater net loss of hospitals and emergency departments between 2010-2019. This finding signals that closures are not isolated incidents at a single point in time. They are contributing to a greater loss of health services for vulnerable communities. While this is an analysis of past trends, the results of the logistic regression indicate that these trends may continue into the future, with communities already experiencing the effect of racial and socioeconomic disparities continuing to bear the brunt of the impact from closures of health facilities.

Socioeconomic Status

The results of the descriptive analysis show that counties with closures of hospitals and emergency departments generally have lower socioeconomic status, with higher percentages of individuals living below the poverty level, higher unemployment rates, higher rates of uninsured individuals, and higher percentages of individuals using food stamps/SNAP benefits. This can partially be explained by the reliance of hospitals on specific payer reimbursement as revenue. There is a range of profitability associated with serving patients with specific insurance types. For example, private insurers that pay a markup above cost generally increase profits for hospitals, whereas patients insured by Medicaid or Medicare and uninsured patients reduce hospital profitability (AHA, 2017; Bai & Anderson, 2016).

Given the nature of reimbursement, and under the theoretical framework of hospitals as profit-maximizing firms, hospitals may be more incentivized to close or close departments when they serve poorer patients. In addition, hospitals specifically serving uninsured patients receive no revenue from reimbursement, so over time, hospitals serving these patients may lose enough money to the point where they are forced to close. The results that poorer counties are disproportionately affected by closures is quite likely linked to this fact.

Beyond the impact of socioeconomic status on a hospital's decision to close, the county-level socioeconomic factors studied in this thesis all directly impact an individual's ability to access health care from an affordability standpoint. Being uninsured reduces opportunities to receive affordable care; living below the poverty level also makes it more difficult to afford care. The general consensus among researchers is that poverty is directly linked to worse health outcomes across a variety of measures, including mortality, heart disease, diabetes, and much more (Khullar & Chokshi, 2018). The results of this thesis indicate that in addition to existing disparities in access and health outcomes for individuals of lower socioeconomic status, disparities relating to hospital and emergency department closures are also unfolding on a national level. The implications of these disparities are discussed further in this section.

Racial Disparities

The results of this thesis show that hospitals and emergency departments in counties with higher percentages of Black and Hispanic individuals were more likely to close between 2010-2019 than counties with lower percentages of these racial groups. Racial minorities, especially Black Americans, already face major disparities in access to health care and in health outcomes across the U.S. Both Black and Hispanic individuals are less likely to have health insurance than White individuals, even after accounting for the implementation of the ACA (11.4% and 20%

uninsured compared to 7.8%) (Artiga et al., 2021). Health insurance directly facilitates access to care, as it reduces the costs for patients seeking routine and unexpected care; thus, the lack of health insurance presents a major barrier to accessing care. From a health perspective, Black individuals also have worse outcomes than non-Black individuals on a variety of measures, including cancer outcomes and complications after surgery (Moss et al., 2022; Ninh et al., 2019). Black Americans are also more likely than White Americans to experience pre-mature mortality from treatable conditions due to a lack of timely access to care (Radley et al., 2021).

This study's findings become particularly relevant when considering the mechanisms by which these disparities exist. The fact that counties with hospital and emergency department closures were composed of more Black and Hispanic individuals than counties without closures may represent the creation of additional disparities in health care access on the basis of race. While this study did not directly measure if access to care was reduced by closures, it is likely that in many cases where hospitals or hospital departments closed (especially non-urban areas), neighboring communities had fewer options for accessing health care. This potential reduction in access appears to have disproportionately impacted communities of color. In addition, if closures occurred in areas without any other major sources of health care, then the closures may have played a role in worsening existing health disparities for Black and Hispanic communities that already suffer from worse health outcomes.

Other Observed Disparities – Housing and Elderly

Disparities in socioeconomic status and race were not the only disparities documented in this study. The results of the SVI quartile analysis and comparative analysis indicate that housing is another area where disparities arise. This thesis assessed housing vulnerability from the perspective of the people who make up households and the perspective of physical household

arrangements (**Figure 1**). This study finds that closures have historically been concentrated in areas with households containing more children, individuals with disabilities, and single parents. Households with these characteristics undoubtedly face many challenges unrelated to health care, but it is not difficult to imagine that any added stress from a hospital closing is likely to exacerbate these challenges. For example, a single parent who has to drive further to a hospital for care while caring for several children may need to coordinate childcare services that were not previously needed. From a physical housing standpoint, closures may not have a direct impact, but they could certainly be related. Studies show that living in crowded housing harms the health and wellbeing of residents, especially children (Solari & Mare, 2012). If a hospital closure does reduce access to care in areas with more crowded housing, then people in those communities with health conditions attributed to their living situation may face difficulty in accessing regular care for their conditions.

The other major disparity outlined in this thesis centers around the elderly population. It is evident from the descriptive analysis that closures over the past 10 years have occurred in counties with smaller elderly populations (**Tables 7-9**). In addition, the percentage of elderly in a county was a negative predictor of hospital and emergency department closure in the regression analyses after controlling for other demographics (**Column VII, Tables 10-11**). This trend can easily be interpreted by once again considering the framework of hospitals as profit-maximizing firms. Elderly patients, specifically those insured by Medicare Advantage plans, can be profitable to serve. The average annual gross margin for a Medicare Advantage member in 2018 was $1,608, almost double that of patients insured in the individual or group market (Jacobson et al., 2019). Hospitals in areas with more patients insured by profitable plans will likely be more financially well-off and less likely to close. This finding offers at least some optimism from this

study's results, as it indicates that closures do not appear to be disproportionately affecting elderly populations. As the number of elderly Americans rises in the coming years, the need for accessible care for elders becomes even more critical, so the fact that hospital and department closures are not currently concentrated in areas with more elderly is a positive sign (Wessel, n.d.).

Variation in County Demographics for Obstetrics Department Closures

Interestingly, obstetrics department closures over the past 10 years do not appear to have been as heavily concentrated in counties with greater vulnerability as defined by this thesis, compared to hospital and emergency department closures. While it is true that over the past decade, counties with obstetrics department closures were more vulnerable on a few SVI and ACS measures than counties without closures and counties without obstetrics departments, the magnitude of these differences was smaller for obstetrics department closures than for emergency departments and hospitals. Counties with obstetrics department closures were generally not much more concentrated in Q4 compared to Q1, and the net loss of these departments over time was minimal, regardless of county vulnerability. The results of the regression also place less importance on the influence of race on the likelihood of closure, as Black race was only significantly associated with closure after controlling for socioeconomic measures and elderly (**Column VII, Table 12**).

This variation in results could be explained by a few factors. In general, obstetrics services are relatively unprofitable for any hospital to offer, regardless of size or location (Horwitz & Nichols, 2022). It seems plausible that more financially solvent hospitals would be more likely to have an obstetrics department to begin with compared to hospitals in financial distress. Hospitals with greater profitability are less likely to be located in counties with higher

percentages of uninsured and poor patients (Bai & Anderson, 2016). Thus, it is possible that the lack of substantial disparities in socioeconomic status for counties with obstetrics department closures is due to the fact that hospitals in more vulnerable areas were less likely to have an obstetrics department to begin with─at least, hospitals in more socioeconomically disadvantaged areas. This theory is supported by the data from this study; on the basis of socioeconomic status as measured by the SVI, only 39.51% of counties in Q4 had at least 1 obstetrics department in 2019, compared to 60.05% of counties in Q1 (**Socioeconomic Status, Column II, Table 3**).

Another factor that may contribute to the disparities in demographics is that nearly 50% of the obstetrics department closures analyzed in this study occurred in rural areas (**Figure 3**). Rural areas in the U.S. are considerably less racially diverse than non-rural areas, and this could explain the absence of substantial racial disparities across counties that did and did not experience obstetrics department closures (Cromartie, 2018). Other factors are likely to contribute to these observations, but what is clear from this thesis is that obstetrics department closures do not follow the same trends as hospital and emergency department closures.

One unexpected finding from the analysis of obstetrics department closures is the negative association between the rate of uninsurance and the likelihood of closure (**Column VII, Table 12**). This result contradicts what is expected, as closures are usually associated with reduced financial performance of hospitals, which is directly linked to revenue from health insurers. Part of this may be explained by the earlier description of why poorer areas may not have as many obstetrics department closures. The high cost associated with running an obstetrics department may outweigh any marginal impact of uninsured patients seeking care; however, this explanation cannot be quantified by this thesis. Perhaps a measure of the rate of uninsured women in a county would more accurately depict the relationship between uninsurance and

obstetrics department closures, but regardless, this remains an interesting trend that would require a more in-depth analysis to understand.

Implications for Access to Health Care

It is not always obvious how closures affect access to health care, since the impact of closures is not uniform across geographies. Rural communities are more likely to face barriers to accessing care when rural hospitals or departments close compared to non-rural communities, as those living in rural areas live farther away from other hospitals where they could receive care (CHQPR, n.d.). However, even non-rural closures can impact access to care and health outcomes if the hospital or department that closes is not incredibly close to another standing hospital. Even a few additional minutes in travel time to a nearby hospital can make a major impact on access to care, especially in urgent situations. Increasing distance to nearby hospitals has been shown to be associated with increased mortality from heart attacks and unintentional injuries, as well as increased mortality after scheduled surgery (Buchmueller et al., 2006; Chou et al., 2014).

Based on this, it is not a stretch to deduce that the closures analyzed in this thesis may play a role in reducing access to overall and emergency care for poorer communities and communities with greater proportions of Black and Hispanic residents, which in turn may be worsening health outcomes. While closures of obstetrics departments may not have the same impact, the nature of obstetrics department closures occurring in rural areas presents its own challenges. Reduced access to obstetrical care in rural areas has been associated with preterm birth and higher risk of birth in hospitals without obstetrics departments (Kozhimannil et al., 2018). Pregnant women are a particularly vulnerable patient population, and increasing distance to a nearby hospital for care can also add challenges throughout the course of pregnancy, as closures could be making it more difficult to receive regular obstetrical care as well.

Unfortunately, the impact of closures is not limited to the time period studied in this thesis. With COVID-19, the rate of hospital closures has accelerated, with 19 hospitals closing in 2020 (and dozens more declaring bankruptcy) (Christensen, 2021). Given this projection, it is likely that emergency department and obstetrics department closures will also continue. The trends outlined in this thesis signal that the possibility of future closures disproportionately harming communities of lower socioeconomic status and communities of color. Current policy proposals aimed at mitigating the effect of hospital closures center around rural hospitals and improving reimbursement from payers (CHQPR, n.d.). However, there may be a need to focus more on supporting hospitals and hospital departments that are the primary source of care in communities with lower socioeconomic status and greater percentages of racial minorities, as these are the communities that appear to disproportionately suffer from closures.

Limitations

This study contained several limitations due to the scope of this thesis, which are discussed below.

Hospital Data Not Inclusive of All U.S. Hospitals

The first limitation stems from the data source relied upon for hospital-level information. The AHA Annual Survey does not contain information about every hospital in the U.S. It is a voluntary survey sent to all U.S. hospitals and health systems; thus, some hospitals do not fill out the survey and are not captured in the data. Since the identification of hospital and hospital department closures relied upon the data in the Annual Survey, there are likely closures that occurred within the period of 2010-2019 that were not captured in this analysis. However, the AHA Annual Survey achieves over a 75% response rate annually, with a total of 6,200+ hospitals and health systems included in the dataset (*Why AHA Data | AHA Data*, n.d.). Because this data source is so large, the key trends found through the analysis of this thesis are likely quite representative of the national trends experienced by most counties due to closures.

Missing County Demographic Data

Another limitation exists due to missing demographic data. Several counties that had hospitals listed in the AHA Annual Survey data did not appear in the demographic data (SVI data, ACS data, or both). As such, the demographics of these counties could not be validated. This resulted in 48 counties with missing data. None of the counties with missing demographic data had been flagged as counties with any type of closure, and the population size for each of these counties was small (below 15,000). Due these characteristics and the potential inaccuracies that would arise with imputing the missing data, these counties were excluded from the analysis.

In addition, there were 3,135 remaining counties with demographic data that were analyzed, so it is unlikely that excluding 48 counties significantly affected the results of this analysis.

Relationship Between County Size and Effects of Closures

The final limitation is due to the imprecision of measuring demographics on a large geographic scale. The use of counties as the unit of geography by which demographics, such as the unemployment rate, are measured introduces a level of ambiguity in terms of interpreting results. Counties vary significantly in size from one another, and as a result, they also have varying numbers of hospitals, emergency departments, and obstetrics departments. It is likely that individuals living in counties with a greater number of hospitals and hospital departments at baseline did not face the same barriers to access created by a closure as individuals living in counties with fewer options for health care. While measuring data at the county-level may oversimplify the inherent differences between county access, it allowed for the visualization of trends on a national level. The demographic data from the ACS 5-year estimates was not available on a national scale at a more specific level of observation. To mitigate some of the variability introduced by the use of counties, weighted means and medians were calculated for the descriptive analysis, based on the relative population size of each county. Several other studies about hospital closures use counties as the unit of geography, so the method used in this analysis is considered acceptable among researchers.

Future Research

Based on the findings from this thesis, there are several directions that future research could take.

Narrowing Geographic Scope

As discussed in the Limitations section, using counties as the unit of geography leads to inherent generalizations that may not arise with a more precise geographic area. Future research should narrow the geographic scope of analyzing closures to focus on the areas directly served by hospitals. Performing a similar analysis as conducted in this thesis on areas that more accurately represent the patient populations of hospitals (for example, hospital service areas) would more accurately depict the relationship between a community's demographics and closures. It could also yield different implications for hospitals, health systems, and policymakers.

Community-Level Impact of Closures

Future research could also take a more community-level approach by directly interviewing community stakeholders in areas where closures have occurred. This would provide a more holistic view of how a hospital or hospital department closure impacts communities. Very few studies analyze the direct impacts of closures on communities from the perspective of the community. Having research that assesses the impact of closures beyond health outcomes or statistical access to care could influence the interventions needed to mitigate the impacts of closures experienced by communities. Even if this type of research does not influence interventions, it would give a voice to the people who must deal with the everyday impact of decisions made by hospitals and health systems about closures.

Role of Consolidation

The final suggestion for future research is to analyze the relationship between consolidation in the hospital industry and hospital closures. For over a decade, the number of mergers and acquisitions of hospitals has been rising (Wirtz, 2015), and the effects of these deals are far-reaching. On one hand, consolidation often helps hospitals by increasing efficiency, reducing operating costs, and/or increasing quality (Robinson, n.d.). In many cases, however, hospital consolidation leads to higher costs passed on to patients (*Hospital Consolidation,* 2020), and it may also yield worse health outcomes (Bindman et al., 1990). The recent spike in consolidation coincides with the rise in hospital and hospital department closures documented in this thesis. However, no major studies assess the relationship between the two trends or if closures that occur as a result of a merger/acquisition disproportionately affect certain communities compared to non-consolidation related closures. If the goal of research about closures is to understand current trends on a deeper level to ensure that access to health care is not reduced for certain populations, then understanding the potential impact of consolidation on closures should also be studied in tandem.

Conclusion

The increase in hospital and hospital department closures over the past decade is cause for concern, as closures often directly impact access to care and health outcomes. This thesis addresses gaps in the literature about the underlying demographics of communities where closures occur. The results of this study show that counties with greater proportions of poorer and Black/Hispanic populations were more likely to experience closures of hospitals and emergency departments between 2010-2019. Obstetrics department closures had a smaller impact on more vulnerable counties, and importantly, they occurred as frequently in rural areas as in non-rural areas, which raises questions about reduced access to obstetrical care in rural America in the coming years. The implications of these findings are dire: socioeconomic and racial disparities are pervasive in many aspects of society, and now, we see that communities already experiencing these disparities must also deal with the potential far-reaching impacts of hospital and hospital department closures. Exactly how this will change moving forward remains unclear, but the sustained trend of disparities in closures over the past 10 years suggests that these disparities will only continue, if not heighten, in the future, unless otherwise addressed.

Acknowledgements

This journey of writing a thesis has been one of the most incredible experiences of my academic career so far. So many aspects of this process have been facilitated by a few key people in my life, and for them, I am eternally grateful. First, to my amazing thesis advisor, Professor Tom Buchmueller, thank you for all your patience with me as I slowly navigated the world of health economics with this topic, and for sharing the many insights you have gained throughout your career with me. To my family and friends, thank you for your unwavering support and confidence in me. To Professor Tasoluk, thank you for guiding the class throughout this year and helping us achieve our research goals. Thank you to Paul Organ, Ph.D., for his support as the class Ph.D. student advisor from day one, and to my SIG group (Phoebe Block, Ananya Sivaraman) for their support and optimism during a challenging year. Finally, a huge thank-you to the other researchers in my life who have taught me statistical techniques, shared their knowledge about the world of health care, and above all, taught me to prioritize the importance of addressing social inequities to make life better for marginalized communities.

Figures/Tables

Figure 1: CDC/ATSDR 2019 Social Vulnerability Index Themes

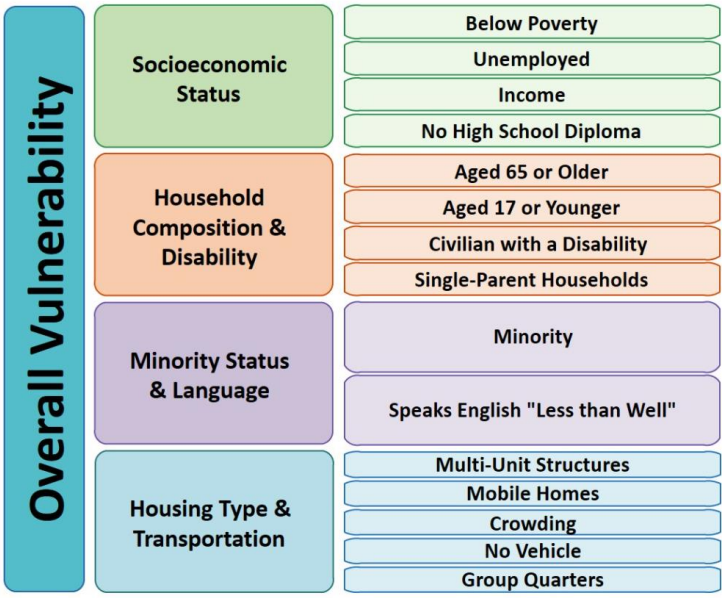

Figure sourced from CDC/ATSDR Social Vulnerability Index website. Figure shows the five themes of vulnerability measured by the Social Vulnerability Index, on a county-level. Themes used in author's descriptive analysis of county vulnerability.

Figure 2: Multivariate Logistic Regression Model

$$\log\frac{p}{1-p} = \beta_0 + \beta_1(\text{Poverty}) + \beta_2(\text{Uninsurance}) + \beta_3(\text{Unemployment}) + \beta_4(\text{Black}) + \beta_5(\text{Hispanic}) + \beta_6(\text{Elderly})$$

Figure shows the basic equation that models the three logistic regressions conducted in this study. The six independent variables shown were chosen due to their limited multicollinearity. The glm package in R was used to create the regression models.

Figure 3: Breakdown of Closures by Rural vs Non-Rural Closures (2010-2019)

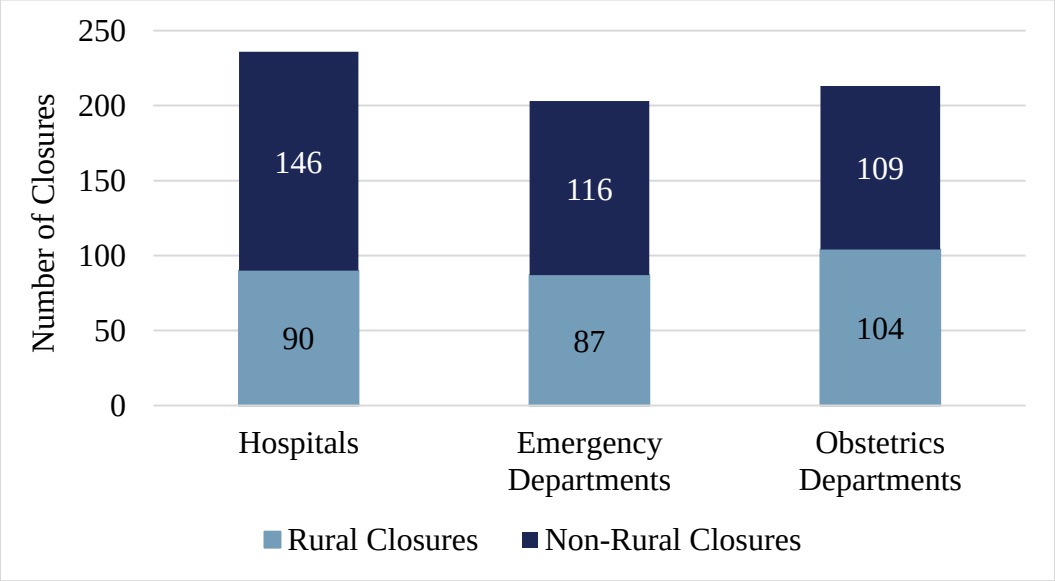

Figure shows the total number of hospital, emergency department, and obstetrics department closures. Each type of closure is also categorized by the number of closures that occurred in rural vs urban areas. Data on rurality sourced from the American Hospital Directory. Data on closures sourced from author's own analysis of closures identified through the AHA Annual Surveys.

Figure 4: Net Change in Hospitals Across County Quartiles (2010-2019)

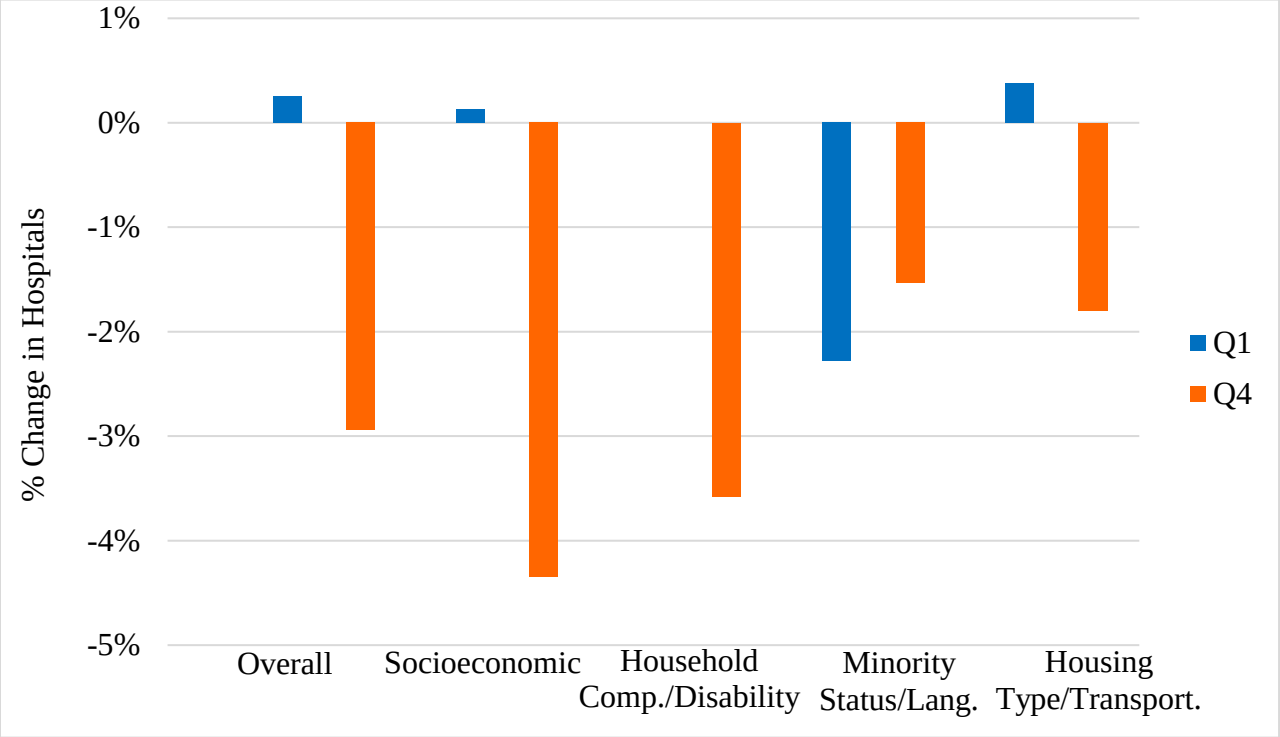

Figure shows net change in hospitals for counties in the most vulnerable and least vulnerable quartiles, over the period 2010-2019. Analysis accounts for hospital openings and closures during this time period. Data on closures sourced from author's own analysis of closures identified through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. Quartile 1 represents the least vulnerable counties (SVI of 0-0.25), and quartile 4 represents the most vulnerable counties (SVI of 0.76-1.0).

Figure 5: Net Change in Emergency Departments Across County Quartiles (2010-2019)

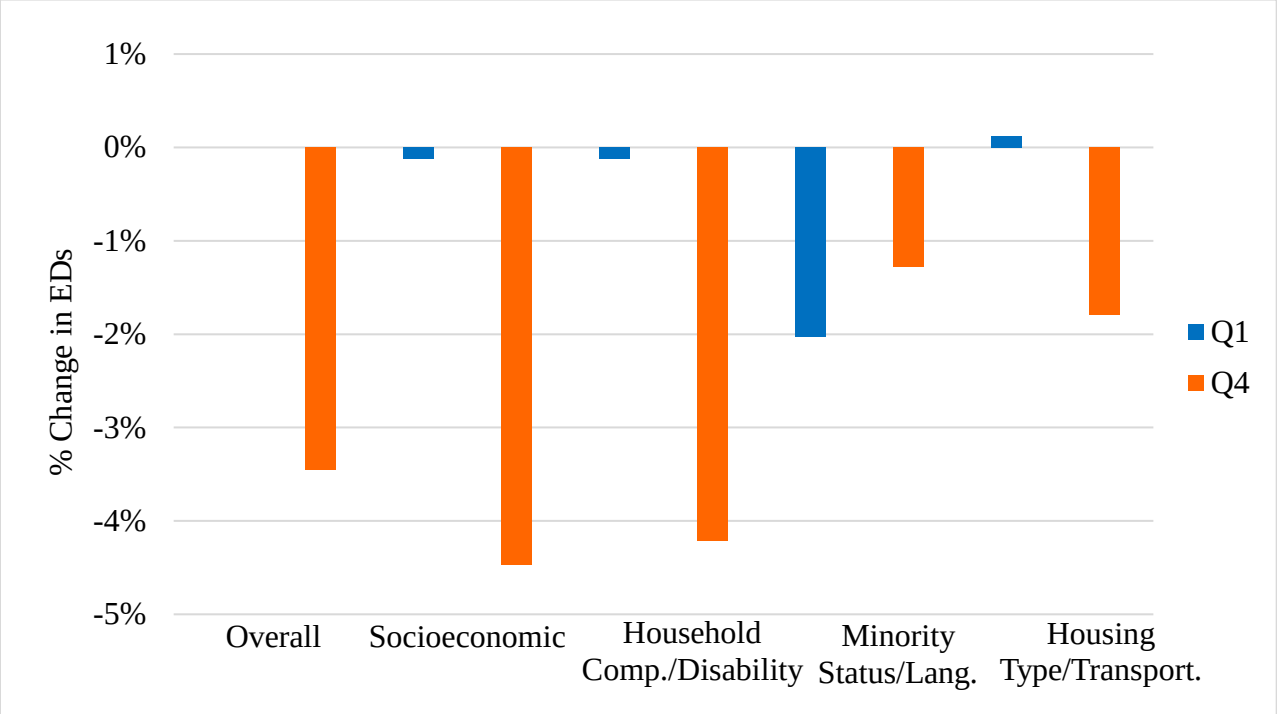

Figure shows net change in emergency departments for counties in the most vulnerable and least vulnerable quartiles, over the period 2010-2019. Analysis accounts for emergency department openings and closures during this time period. Data on closures sourced from author's own analysis of closures identified through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. Quartile 1 represents the least vulnerable counties (SVI of 0-0.25), and quartile 4 represents the most vulnerable counties (SVI of 0.76-1.0).

Figure 6: Net Change in Obstetrics Departments Across County Quartiles (2010-2019)

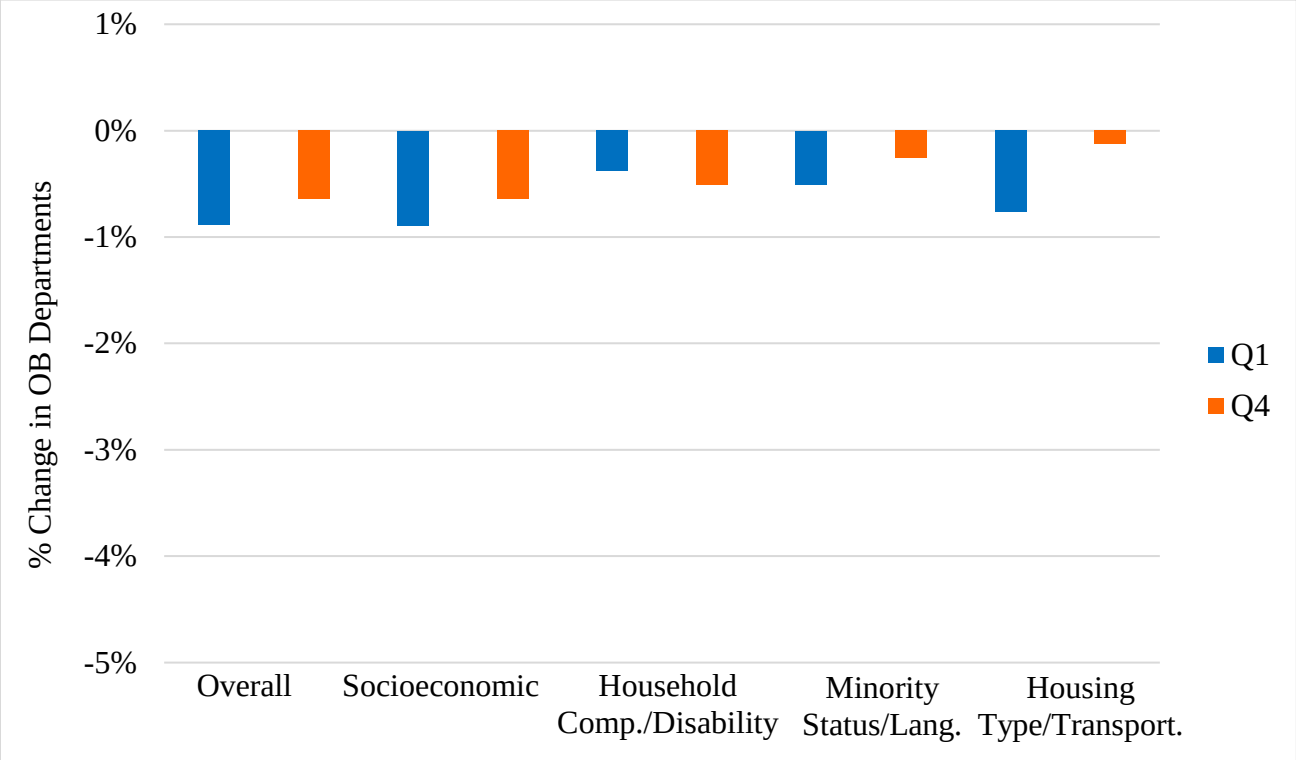

Figure shows net change in obstetrics departments for counties in the most vulnerable and least vulnerable quartiles, over the period 2010-2019. Analysis accounts for obstetrics department openings and closures during this time period. Data on closures sourced from author's own analysis of closures identified through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. Quartile 1 represents the least vulnerable counties (SVI of 0-0.25), and quartile 4 represents the most vulnerable counties (SVI of 0.76-1.0).

Figure 7: Comparing Predicting Likelihood of Closures Across County Quartiles (Multivariate Regression)

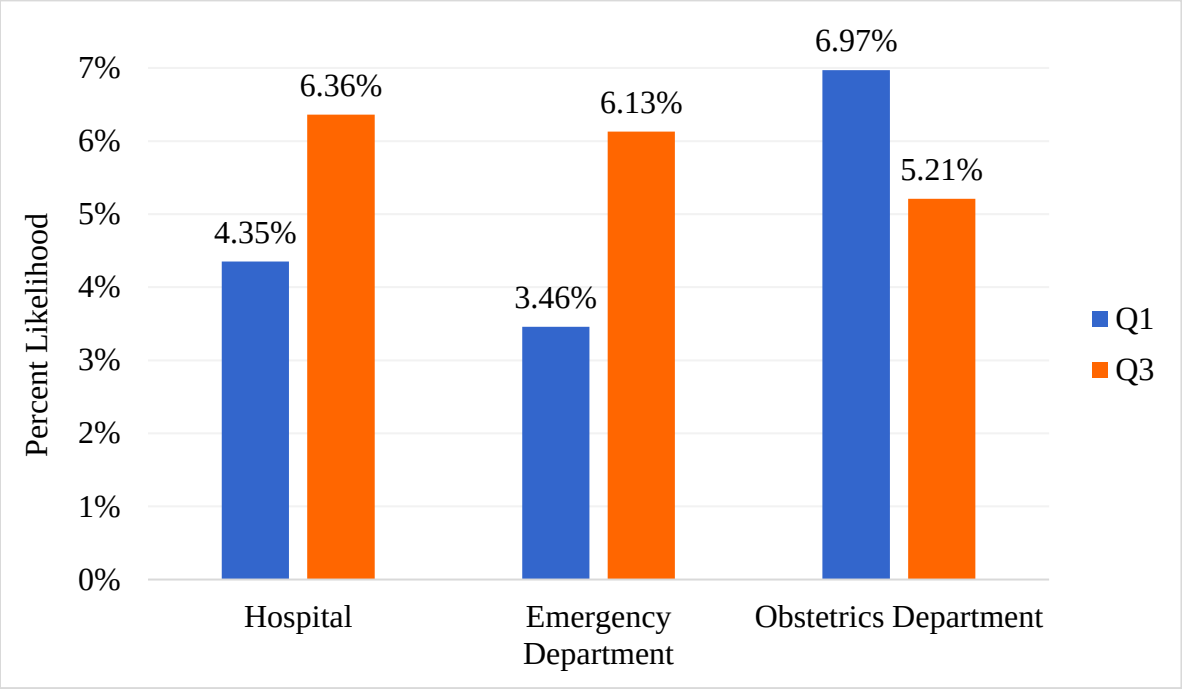

Figure shows application of multivariate logistic regression models assessing likelihood of counties experiencing closures on basis of six independent variables: Hispanic, Black, poverty, uninsurance, unemployment, and elderly. County data on the 25th percentile of each independent variable was categorized as Q1; county data on the 75th percentile of each independent variable was categorized as Q3. This data was used in each of the three regression models (for hospitals, emergency departments, and obstetrics departments) to calculate the predicted probability of a closure. Independent variables sourced from the American Community Survey; dependent variable of experiencing a closure sourced from author's own analysis of closures identified through the AHA Annual Surveys. Predictions conducted by inputting 25th and 75th percentile data values into logistic regression equations and calculating the probability of experiencing a closure.

Table 1: SVI Quartile Analysis – Hospitals

	% Counties With ≥1 Hospital			% Counties With ≥1 Hospital Closure
Overall Vulnerability	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	74.24%	74.49%	0.25%	1.78%
Q2	80.59%	80.08%	-0.51%	5.10%
Q3	82.61%	79.03%	-3.58%	8.95%
Q4	82.10%	79.16%	-2.94%	9.72%
Socioeconomic Status	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	80.79%	80.92%	0.13%	3.05%
Q2	81.99%	81.23%	-0.77%	6.51%
Q3	80.61%	78.83%	-1.79%	8.16%
Q4	76.09%	71.74%	-4.35%	7.80%
Household Composition/Disability	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	79.62%	79.62%	0.00%	6.11%
Q2	78.88%	77.86%	-1.02%	4.96%
Q3	80.54%	78.36%	-2.18%	6.79%
Q4	80.46%	76.88%	-3.58%	7.66%
Minority Status/Language	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	71.77%	69.49%	-2.28%	2.53%
Q2	77.28%	76.25%	-1.03%	3.34%
Q3	83.55%	81.63%	-1.91%	7.91%
Q4	86.96%	85.42%	-1.53%	11.76%
Housing Type/Transportation	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	65.99%	66.37%	0.38%	1.90%
Q2	78.98%	76.18%	-2.80%	6.24%
Q3	86.97%	84.42%	-2.55%	8.43%
Q4	87.68%	85.88%	-1.80%	8.92%

Figure shows changes in access to hospitals for counties over the period 2010-2019, on the basis of county vulnerability. Data on closures sourced from author's own analysis of closures identified through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. The rows correspond to the quartile of vulnerability a county belongs to: Q1 (0-0.25); Q2 (0.26-0.50); Q3 (0.51-0.75); and Q4 (0.76-1.0).

Table 2: SVI Quartile Analysis – Emergency Departments

	% Counties With ≥1 Emergency Department			% Counties With ≥1 Emergency Department Closure
Overall Vulnerability	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	74.49%	74.49%	0.00%	1.14%
Q2	80.72%	80.20%	-0.51%	4.60%
Q3	82.10%	79.03%	-3.07%	7.42%
Q4	82.48%	79.03%	-3.45%	9.34%
Socioeconomic Status	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	81.04%	80.92%	-0.13%	2.29%
Q2	82.12%	81.48%	-0.64%	5.24%
Q3	80.61%	78.83%	-1.79%	7.27%
Q4	75.96%	71.48%	-4.48%	7.67%
Household Composition/Disability	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	79.75%	79.62%	-0.13%	4.84%
Q2	79.01%	78.37%	-0.64%	3.94%
Q3	80.41%	78.36%	-2.05%	6.27%
Q4	80.59%	76.37%	-4.21%	7.41%
Minority Status/Language	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	71.65%	69.62%	-2.03%	2.28%
Q2	77.54%	75.87%	-1.67%	3.34%
Q3	83.67%	81.63%	-2.04%	7.65%
Q4	86.96%	85.68%	-1.28%	9.21%
Housing Type/Transportation	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	66.12%	66.24%	0.13%	1.90%
Q2	78.73%	76.18%	-2.55%	5.35%
Q3	87.23%	84.42%	-2.81%	7.15%
Q4	87.80%	86.01%	-1.80%	8.03%

Figure shows changes in access to emergency departments for counties over the period 2010-2019, on the basis of county vulnerability. Data on closures sourced from author's own analysis of closures identified through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. The rows correspond to the quartile of vulnerability a county belongs to: Q1 (0-0.25); Q2 (0.26-0.50); Q3 (0.51-0.75); and Q4 (0.76-1.0).

Table 3: SVI Quartile Analysis – Obstetrics Departments

	% Counties With ≥1 Obstetrics Department			% Counties With ≥1 Obstetrics Department Closure
Overall Vulnerability	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	52.66%	51.78%	-0.89%	5.08%
Q2	58.75%	58.49%	-0.26%	6.00%
Q3	58.06%	58.06%	0.00%	8.31%
Q4	52.43%	51.79%	-0.64%	5.50%
Socioeconomic Status	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	60.94%	60.05%	-0.89%	5.73%
Q2	63.60%	63.47%	-0.13%	7.92%
Q3	57.14%	57.02%	-0.13%	6.38%
Q4	40.15%	39.51%	-0.64%	4.86%
Household Composition/Disability	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	64.08%	63.69%	-0.38%	7.39%
Q2	53.82%	53.56%	-0.25%	6.11%
Q3	56.72%	56.08%	-0.64%	6.66%
Q4	47.25%	46.74%	-0.51%	4.73%
Minority Status/Language	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	39.75%	39.24%	-0.51%	5.44%
Q2	52.89%	52.25%	-0.64%	4.36%
Q3	59.82%	59.44%	-0.38%	5.48%
Q4	69.57%	69.31%	-0.26%	9.59%
Housing Type/Transportation	**I. 2010**	**II. 2019**	**III. Δ%**	**IV**
Q1	37.44%	36.68%	-0.76%	3.93%
Q2	51.72%	51.34%	-0.38%	4.84%
Q3	65.26%	64.75%	-0.51%	9.07%
Q4	67.65%	67.52%	-0.13%	7.01%

Figure shows changes in access to obstetrics departments for counties over the period 2010-2019, on the basis of county vulnerability. Data on closures sourced from author's own analysis of closures identified through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. The rows correspond to the quartile of vulnerability a county belongs to: Q1 (0-0.25); Q2 (0.26-0.50); Q3 (0.51-0.75); and Q4 (0.76-1.0).

Table 4: SVI Quartile Analysis – Beds/Capita per 1,000

	Beds/Capita per 1,000		
Overall Vulnerability	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	1.51	1.41	-10.40%
Q2	1.95	1.61	-34.84%
Q3	2.13	1.81	-32.20%
Q4	2.17	1.83	-34.10%
Socioeconomic Status	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	1.85	1.66	-18.85%
Q2	2.05	1.76	-29.05%
Q3	2.04	1.70	-34.45%
Q4	1.94	1.61	-32.99%
Household Composition/Disability	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	1.65	1.56	-8.97%
Q2	1.91	1.60	-31.01%
Q3	2.11	1.80	-30.85%
Q4	2.22	1.79	-43.25%
Minority Status/Language	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	1.87	1.47	-39.52%
Q2	1.97	1.66	-30.91%
Q3	1.96	1.72	-24.12%
Q4	2.06	1.83	-22.82%
Housing Type/Transportation	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	1.25	1.13	-12.40%
Q2	1.70	1.44	-26.73%
Q3	2.38	1.95	-42.78%
Q4	2.42	2.11	-31.24%

Figure shows changes in beds per capita per 1,000 for counties over the period 2010-2019, on the basis of county vulnerability. Beds per capita calculated from author's own analysis of hospital data through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. The rows correspond to the quartile of vulnerability a county belongs to: Q1 (0-0.25); Q2 (0.26-0.50); Q3 (0.51-0.75); and Q4 (0.76-1.0).

Table 5: SVI Quartile Analysis - Emergency Departments/Capita per 10,000

	Emergency Departments/Capita per 10,000		
Overall Vulnerability	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.23	0.23	0.55%
Q2	0.23	0.22	-0.99%
Q3	0.24	0.21	-3.78%
Q4	0.33	0.30	-3.64%
Socioeconomic Status	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.23	0.23	0.80%
Q2	0.22	0.21	-1.65%
Q3	0.26	0.23	-2.72%
Q4	0.36	0.31	-5.23%
Household Composition/Disability	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.15	0.14	-0.53%
Q2	0.25	0.25	-0.48%
Q3	0.30	0.27	-2.51%
Q4	0.37	0.32	-5.59%
Minority Status/Language	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.38	0.35	-2.97%
Q2	0.29	0.28	-0.97%
Q3	0.22	0.19	-2.39%
Q4	0.19	0.18	-1.67%
Housing Type/Transportation	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.20	0.20	0.00%
Q2	0.25	0.22	-2.45%
Q3	0.28	0.26	-1.68%
Q4	0.28	0.25	-3.24%

Figure shows changes in emergency departments per capita per 10,000 for counties over the period 2010-2019, on the basis of county vulnerability. Emergency departments per capita calculated from author's own analysis of hospital data through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. The rows correspond to the quartile of vulnerability a county belongs to: Q1 (0-0.25); Q2 (0.26-0.50); Q3 (0.51-0.75); and Q4 (0.76-1.0).

Table 6: SVI Quartile Analysis - Obstetrics Departments/Capita per 10,000

	Obstetrics Departments/Capita per 10,000		
Overall Vulnerability	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.042	0.034	-0.79%
Q2	0.069	0.068	-0.06%
Q3	0.067	0.068	0.11%
Q4	0.047	0.044	-0.34%
Socioeconomic Status	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.065	0.064	-0.15%
Q2	0.086	0.083	-0.27%
Q3	0.075	0.075	0.00%
Q4	0.000	0.000	0.00%
Household Composition/Disability	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.064	0.063	-0.04%
Q2	0.054	0.053	-0.12%
Q3	0.076	0.074	-0.26%
Q4	0.000	0.000	0.00%
Minority Status/Language	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.000	0.000	0.00%
Q2	0.071	0.065	-0.59%
Q3	0.075	0.074	-0.14%
Q4	0.071	0.070	-0.03%
Housing Type/Transportation	**I. 2010**	**II. 2019**	**III. Δ%**
Q1	0.000	0.000	0.00%
Q2	0.044	0.040	-0.40%
Q3	0.110	0.108	-0.13%
Q4	0.109	0.106	-0.23%

Figure shows changes in obstetrics departments per capita per 10,000 for counties over the period 2010-2019, on the basis of county vulnerability. Obstetrics departments per capita calculated from author's own analysis of hospital data through the AHA Annual Surveys. Vulnerability data sourced from the Social Vulnerability Index (SVI), with all five themes analyzed. The SVI ranges from 0 to 1, with 1 representing the highest level of vulnerability. The rows correspond to the quartile of vulnerability a county belongs to: Q1 (0-0.25); Q2 (0.26-0.50); Q3 (0.51-0.75); and Q4 (0.76-1.0).

Table 7: Comparative Analysis of County Demographics – Hospital Closures

Hospitals - Mean						
N = 3,078	**Counties Without Closures (N = 2,275)**		**Counties With Closures (N = 199)**		**Counties Without Hospitals (N = 604)**	
	Unweighted	**Weighted**	**Unweighted**	**Weighted**	**Unweighted**	**Weighted**
Overall Vulnerability	0.06	0.31	0.64	0.65	0.45	0.44
Socioeconomic Status	0.05	0.22	0.58	0.52	0.52	0.49
Household Composition/Disability	0.50	0.34	0.53	0.35	0.50	0.50
Minority Status/Language* **	0.51	0.71	0.67	0.89	0.40	0.43
Housing Type/Transportation* **	0.52	0.58	0.63	0.71	0.37	0.40
Poverty* **	14.87%	12.99%	16.49%	14.56%	15.29%	13.43%
Unemployment* **	5.21%	5.28%	6.01%	5.73%	5.22%	5.03%
Uninsurance* **	9.37%	8.28%	10.61%	10.35%	10.31%	8.60%
Stamp/SNAP Benefits* **	12.50%	11.23%	14.45%	13.00%	12.96%	11.19%
Black Race* **	8.44%	11.36%	14.93%	16.34%	8.53%	9.35%
Hispanic Race* **	9.38%	14.64%	12.99%	27.66%	8.60%	11.02%
Elderly* **	18.49%	16.03%	17.52%	14.37%	20.34%	17.36%
Hospitals - Median						
	Counties Without Closures (N = 2,275)		**Counties With Closures (N = 199)**		**Counties Without Hospitals (N = 604)**	
	Unweighted	**Weighted**	**Unweighted**	**Weighted**	**Unweighted**	**Weighted**
Overall Vulnerability	0.49	0.49	0.67	0.67	0.44	0.44
Socioeconomic Status	0.48	0.36	0.59	0.52	0.54	0.50
Household Composition/Disability	0.50	0.28	0.55	0.34	0.49	0.52
Minority Status/Language	0.51	0.77	0.73	0.96	0.37	0.43
Housing Type/Transportation	0.53	0.64	0.64	0.74	0.31	0.39
Poverty	14.00%	12.20%	15.70%	14.90%	14.00%	12.40%
Unemployment	4.90%	5.10%	5.60%	5.63%	4.70%	4.60%
Uninsurance	8.40%	7.60%	10.00%	9.60%	9.20%	8.30%
Stamp/SNAP Benefits	11.70%	10.40%	13.30%	12.52%	11.40%	9.80%
Black Race	2.20%	6.50%	9.20%	13.50%	1.20%	5.74%
Hispanic Race	4.40%	9.20%	7.30%	25.27%	3.05%	5.00%
Elderly	18.20%	15.40%	17.30%	14.07%	19.90%	17.20%

Figure compares the mean and median vulnerability metrics of counties that did not experience hospital closures to counties that experienced hospital closures and to counties that had no hospitals between 2010-2019. Closures were calculated from author's own analysis of hospital

*data through the AHA Annual Surveys. All five measures of vulnerability from the Social Vulnerability Index were assessed, as well as all seven metrics from the American Community Survey. The Social Vulnerability Index values range from 0-1, with 1 representing the highest level of vulnerability. Weighted analyses of the mean and median were conducted using the county population as the measure of weight, where larger counties were assigned a greater weight in the calculation of the mean and median. ANOVA tests were conducted using R to measure the significance levels between the means of the categories of counties. Significance assigned according to the following p-value scale: *** if <0.01, ** if <0.05, and * if <0.1.*

Table 8: Comparative Analysis of County Demographics – Emergency Department Closures

Emergency Departments - Mean						
N = 3,074	**Counties Without Closures (N = 2,297)**		**Counties With Closures (N = 176)**		**Counties Without Emergency Departments (N = 601)**	
	Unweighted	**Weighted**	**Unweighted**	**Weighted**	**Unweighted**	**Weighted**
Overall Vulnerability	0.06	0.35	0.65	0.55	0.45	0.51
Socioeconomic Status	0.05	0.26	0.61	0.41	0.52	0.54
Household Composition/Disability*	0.50	0.35	0.55	0.27	0.50	0.53
Minority Status/Language***	0.51	0.73	0.66	0.84	0.40	0.50
Housing Type/Transportation***	0.52	0.60	0.63	0.66	0.37	0.44
Poverty***	14.85%	13.08%	16.87%	13.99%	15.33%	14.56%
Unemployment***	5.20%	5.33%	6.07%	5.59%	5.22%	5.49%
Uninsurance***	9.35%	8.37%	10.82%	9.48%	10.33%	8.91%
Stamp/SNAP Benefits***	12.48%	11.23%	14.82%	12.29%	12.96%	12.34%
Black Race***	8.49%	11.78%	14.77%	17.11%	8.58%	10.11%
Hispanic Race**	9.51%	16.52%	12.00%	21.92%	8.63%	11.75%
Elderly***	18.46%	15.83%	17.94%	14.62%	20.34%	17.53%
Emergency Departments - Median						
	Counties Without Closures (N = 2,297)		**Counties With Closures (N = 176)**		**Counties Without Emergency Departments (N = 601)**	
	Unweighted	**Weighted**	**Unweighted**	**Weighted**	**Unweighted**	**Weighted**
Overall Vulnerability	0.49	0.51	0.69	0.67	0.44	0.44
Socioeconomic Status	0.47	0.38	0.63	0.52	0.54	0.50
Household Composition/Disability	0.49	0.29	0.59	0.33	0.49	0.53
Minority Status/Language	0.52	0.80	0.72	0.95	0.37	0.43
Housing Type/Transportation	0.53	0.65	0.65	0.73	0.31	0.38
Poverty	14.00%	12.70%	16.00%	15.10%	14.00%	12.27%
Unemployment	4.90%	5.10%	5.60%	5.47%	4.70%	4.60%
Uninsurance	8.40%	7.80%	10.40%	9.42%	9.20%	8.30%
Stamp/SNAP Benefits	11.70%	10.30%	13.95%	13.00%	11.40%	9.80%
Black Race	2.30%	7.56%	8.70%	17.33%	1.20%	5.70%
Hispanic Race	4.40%	10.09%	6.70%	24.95%	3.00%	5.20%

Elderly	18.20%	15.20%	17.45%	14.36%	19.90%	17.20%

*Figure compares the mean and median vulnerability metrics of counties that did not experience emergency department closures to counties that experienced emergency department closures and to counties that had no emergency departments between 2010-2019. Closures were calculated from author's own analysis of hospital data through the AHA Annual Surveys. All five measures of vulnerability from the Social Vulnerability Index were assessed, as well as all seven metrics from the American Community Survey. The Social Vulnerability Index values range from 0-1, with 1 representing the highest level of vulnerability. Weighted analyses of the mean and median were conducted using the county population as the measure of weight, where larger counties were assigned a greater weight in the calculation of the mean and median. ANOVA tests were conducted using R to measure the significance levels between the means of the categories of counties. Significance assigned according to the following p-value scale: *** if <0.01, ** if <0.05, and * if <0.1.*

Table 9: Comparative Analysis of County Demographics – Obstetrics Department Closures

Obstetrics Departments - Mean						
N = 3,117	**Counties Without Closures (N = 1,540)**		**Counties With Closures (N = 183)**		**Counties Without Obstetrics Departments (N = 1,384)**	
	Unweighted	**Weighted**	**Unweighted**	**Weighted**	**Unweighted**	**Weighted**
Overall Vulnerability	0.08	0.35	0.52	0.55	0.48	0.51
Socioeconomic Status	0.12	0.25	0.48	0.41	0.54	0.54
Household Composition/Disability* **	0.47	0.35	0.45	0.27	0.53	0.53
Minority Status/Language* **	0.54	0.76	0.57	0.84	0.42	0.50
Housing Type/Transportation **	0.55	0.62	0.57	0.66	0.41	0.44
Poverty* **	14.76%	13.14%	14.69%	13.99%	15.60%	14.56%
Unemployment	5.27%	5.34%	5.29%	5.59%	5.30%	5.49%
Uninsurance* **	9.26%	8.67%	8.96%	9.48%	10.22%	8.91%
Stamp/SNAP Benefits* **	12.44%	11.46%	13.20%	12.29%	13.09%	12.34%
Black Race*	8.55%	11.84%	10.41%	17.11%	9.35%	10.11%
Hispanic Race* **	10.32%	17.94%	9.75%	21.92%	7.96%	11.75%
Elderly* **	17.82%	15.64%	18.23%	14.62%	20.18%	17.53%
Obstetrics Departments - Median						
	Counties Without Closures (N = 1,540)		**Counties With Closures (N = 183)**		**Counties Without Obstetrics Departments (N = 1,384)**	
	Unweighted	**Weighted**	**Unweighted**	**Weighted**	**Unweighted**	**Weighted**
Overall Vulnerability	0.50	0.52	0.54	0.63	0.48	0.52
Socioeconomic Status	0.45	0.38	0.46	0.42	0.57	0.56
Household Composition/Disability	0.47	0.28	0.43	0.20	0.53	0.54
Minority Status/Language	0.56	0.83	0.61	0.92	0.39	0.52
Housing Type/Transportation	0.57	0.67	0.60	0.71	0.37	0.43
Poverty	14.00%	13.00%	13.80%	14.37%	14.65%	13.50%
Unemployment	5.00%	5.20%	5.00%	5.50%	4.90%	4.80%
Uninsurance	8.30%	8.20%	7.80%	8.39%	9.30%	8.30%
Stamp/SNAP Benefits	11.80%	10.50%	12.60%	12.52%	12.10%	11.30%
Black Race	2.70%	8.06%	4.30%	13.79%	1.55%	4.10%
Hispanic Race	5.10%	10.42%	5.60%	19.30%	3.10%	5.40%
Elderly	17.50%	15.10%	17.80%	14.40%	19.80%	17.40%

*Figure compares the mean and median vulnerability metrics of counties that did not experience obstetrics department closures to counties that experienced obstetrics department closures and to counties that had no obstetrics departments between 2010-2019. Closures were calculated from author's own analysis of hospital data through the AHA Annual Surveys. All five measures of vulnerability from the Social Vulnerability Index were assessed, as well as all seven metrics from the American Community Survey. The Social Vulnerability Index values range from 0-1, with 1 representing the highest level of vulnerability. Weighted analyses of the mean and median were conducted using the county population as the measure of weight, where larger counties were assigned a greater weight in the calculation of the mean and median. ANOVA tests were conducted using R to measure the significance levels between the means of the categories of counties. Significance assigned according to the following p-value scale: *** if <0.01, ** if <0.05, and * if <0.1.*

Table 10: Regression Results – Hospital Closures

	I	II	III	IV	V	VI	VII
Hispanic	0.117*** (0.031)	-	-	-	-	-	0.122*** (0.035)
Black	-	0.177*** (0.030)	-	-	-	-	0.169*** (0.035)
Poverty	-	-	0.225*** (0.069)	-	-	-	-0.065 (0.097)
Uninsured	-	-	-	0.247*** (0.086)	-	-	-0.002 (0.102)
Unemployment	-	-	-	-	0.678*** (0.167)	-	0.323 (0.219)
Elderly	-	-	-	-	-	-0.366*** (0.094)	-0.171* (0.098)

*Figure shows results of univariate and multivariate logistic regression conducted in R. The coefficients and significance levels are included, and the standard errors are in parentheses below each coefficient. Independent variables included in analysis on basis of variance inflation factor (VIF) below 3, indicating low multicollinearity. Dependent variable assigned as binary variable indicating a hospital closure in a county (1 for experiencing a minimum of 1 closure, 0 if no closures). Independent variables sourced from the American Community Survey; dependent variable sourced from author's own analysis of closures identified through the AHA Annual Surveys. Coefficients and standard error values are scaled by a factor of 100. Significance assigned according to the following p-value scale: *** if <0.01, ** if <0.05, and * if <0.1.*

Table 11: Regression Results – Emergency Department Closures

	I	II	III	IV	V	VI	VII
Hispanic	0.075** (0.030)	-	-	-	-	-	0.072** (0.033)
Black	-	0.152*** (0.028)	-	-	-	-	0.132*** (0.033)
Poverty	-	-	0.249*** (0.065)	-	-	-	0.004 (0.092)
Uninsured	-	-	-	0.257*** (0.081)	-	-	0.066 (0.096)
Unemployment	-	-	-	-	0.646*** (0.157)	-	0.272 (0.207)
Elderly	-	-	-	-	-	-0.224** (0.088)	-0.066 (0.093)

*Figure shows results of univariate and multivariate logistic regression conducted in R. The coefficients and significance levels are included, and the standard errors are in parentheses below each coefficient. Independent variables included in analysis on basis of variance inflation factor (VIF) below 3, indicating low multicollinearity. Dependent variable assigned as binary variable indicating an emergency department closure in a county (1 for experiencing a minimum of 1 closure, 0 if no closures). Independent variables sourced from the American Community Survey; dependent variable sourced from author's own analysis of closures identified through the AHA Annual Surveys. Coefficients and standard error values are scaled by a factor of 100. Significance assigned according to the following p-value scale: *** if <0.01, ** if <0.05, and * if <0.1.*

Table 12: Regression Results – Obstetrics Department Closures

	I	II	III	IV	V	VI	VII
Hispanic	0.011 (0.031)	-	-	-	-	-	0.040 (0.035)
Black	-	0.040 (0.030)	-	-	-	-	0.060* (0.035)
Poverty	-	-	-0.065 (0.068)	-	-	-	-0.098 (0.097)
Uninsured	-	-	-	-0.160* (0.085)	-	-	-0.217** (0.101)
Unemployment	-	-	-	-	0.009 (0.165)	-	0.099 (0.218)
Elderly	-	-	-	-	-	-0.164* (0.093)	-0.146 (0.098)

*Figure shows results of univariate and multivariate logistic regression conducted in R. The coefficients and significance levels are included, and the standard errors are in parentheses below each coefficient. Independent variables included in analysis on basis of variance inflation factor (VIF) below 3, indicating low multicollinearity. Dependent variable assigned as binary variable indicating an obstetrics department closure in a county (1 for experiencing a minimum of 1 closure, 0 if no closures). Independent variables sourced from the American Community Survey; dependent variable sourced from author's own analysis of closures identified through the AHA Annual Surveys. Coefficients and standard error values are scaled by a factor of 100. Significance assigned according to the following p-value scale: *** if <0.01, ** if <0.05, and * if <0.1.*

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