Distance and Quality Tradeoff: The Tale of US Rural Mothers*

Ernest Dorilas†

Georgia State University

Abstract

Expecting mothers in rural areas face a tradeoff between hospital quality and distance traveled to deliver their babies. We utilize a hospital choice framework to examine this tradeoff using the Vitals Statistics Birth Records and the American Hospital Association annual surveys over 2007-2017. We find that rural pregnant mothers have negative marginal utility for distance traveled as further distances are associated with additional transportation costs, opportunity cost of time, and discomfort for a pregnant woman. We also find that mothers value the characteristics of obstetric beds, bassinets (beds for babies), Neonate Intensive Care Unit hospitals (NICU), hospitals accredited by the Joint Commission, public and non-profit hospitals. More specifically, high-risk mothers are willing to travel 9.5% more miles (relative to the mean) to go to any NICU hospital. NICU hospitals may represent an emergency exit plan for mothers who expect a challenging birth. These findings have important policy relevance for Certificate of Need Laws (CON), given the obstetric care shortage and the closures of many rural hospitals.

Keywords: Availability of Care, Accessibility of Care, Quality of Care, Rural Health
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†Ph.D. candidate: Department of Economics, Andrew Young School of Policy Studies, Georgia State University, Atlanta, GA. E-mail: edorilas1@student.gsu.edu

1 Introduction

In the United States, mothers living in rural areas face substantial disparity in accessing medical care of good quality (Douthit et al. (2015), Kozhimannil et al. (2019)). Numerous clinical factors such as rising cost of care, low Medicaid reimbursement rates, and competition from urban hospitals adversely impact rural health facilities and the quality of services provided (Roh et al., 2008). These conditions, among others, led to the closure of 181 hospitals in rural areas since 2005 (Cecil, 2020). Over 10% of rural women drive more than 100 miles for maternity care (CMS, 2018). Moreover, evidence supports that several patients who access rural hospitals report on their low quality care and poor reputation (Taylor and Cosenza (1999); Liu et al. (2007)). As a result, many of them bypass their local facilities for more distant hospitals (Bronstein and Morrisey (1991), Premkumar et al. (2016)).

In this paper, we answer the following questions: how many more miles are rural mothers willing to travel to a high-quality hospital? And, how does this tradeoff vary by age, race, education, risk level, and types of insurance coverage? These questions matter because 35% of all US counties have no hospital providing obstetric services (Dimes, 2018), and women living in communities with obstetric care shortages have a higher proportion of delivery complications, higher rates of premature births, and greater neonatal care costs than other women (Nesbitt et al., 1990). Distance traveled is associated with a reduction in health care utilization, higher rates of c-section and neonatal hypoglycemia (Robbins et al., 2019), and higher rates of adverse perinatal outcomes (Grzybowski et al. (2011), Ravelli et al. (2011)).

To estimate the tradeoff between hospital quality and distance, we use the 2007-2017 Vital Statistics Data Files (birth records) and the American Hospital Association (AHA) annual surveys. Because the restricted version of the birth records that we use does not include the address and the hospital of birth of the patient, we use the centroids of the county of residence and birth occurrence for the analysis. We develop a three-step method to investigate the tradeoff of interest. First, we create a small dataset that enables us to identify all the counties within a radius of 50 miles of each specific county. We create a “ghost” county for all the counties that are outside of the 50 miles. We consider 50 miles as the defined market area after several considerations such as distance traveled distributions and Federal regulations related to the establishment of small rural hospitals such as Critical Access Hospitals (CAH) and Sole Community Hospitals (SCH). Second, we merge the small dataset with the natality files using the county of residence. This step enables us to observe all the potential counties where the individual could give birth in the country (within the 50 miles radius + outside the 50 miles radius through the “ghost” county). Finally, we merge the obtained dataset with the hospital records to match births with hospitals. For the “ghost” county, we create a single “ghost” hospital to which we impute the average hospital characteristics. We yield a total of 113,488,826 birth-hospital matched observations for a total of 6,039,936 rural residing mothers who gave birth between 2007 and 2017, where the average mother has 18 hospitals in her choice set.

Even after merging birth records and hospital data, we still do not know the chosen hospital while we can identify the county of birth occurrence, which may have several hospitals. A simple conditional logit (fixed-effect logit model) would suffice to estimate the model if we knew the selected hospital. To go around this issue, we utilize a maximum likelihood estimation procedure that aggregates the probability of choosing any hospital within a county as the sum of the probabilities of selecting each hospital within the county. Many rural counties have only one hospital, and for mothers choosing such a county the probability of that county is exactly a conditional logit formulation.

The numerical estimation of the maximum likelihood is identified by variations in hospital features (size, demand, cost, number of maternity care providers with admitting privileges, number of registered nurses, etc.), community characteristics (economic condition, Medicaid expansion, obstetric reimbursement rates, Certificate of Need Laws, immigrant childbirth-friendly policies), and choice set features (bypass phenomenon, going beyond the defined market area). Given that this is a within-individual framework, all factors that stay constant within individuals across hospitals (e.g., age, education, etc.) will not impact the choice model unless they are interacted with hospital characteristics. This random utility model determines strict utilities that capture the desirability of hospital alternatives. It is rooted in the utility maximization theory and has a compensatory or tradeoff interpretation between the explanatory variables.

Specifically, to estimate the tradeoff of interest, we apply great-circle or spherical distances to proxy for road distance or actual travel times. Spherical distances characterize the shortest distance between two points (the centroid of the county of residence and a potential birth occurrence county). Given that hospital quality is a multifaceted object, we employ different measures of quality such as hospital accreditation by the Joint Commission, an indicator for Neonate Intensive Care Units (NICU), number of obstetric beds and bassinets (beds for babies), hospital teaching status, and indicators for public and non-profit hospitals. These hospital quality indicators refer to the process of care contrary to other hospital quality metrics used in the literature such as mortality rates and readmission rates, which pose selection issues and necessitate an adjustment in differences in case-mix, which is controversial (**?**).

The results show that rural mothers have negative marginal utility for distance and positive marginal utility for hospital quality. Mothers are willing to travel 0.03 miles and 0.0413 miles for a one-unit increase in obstetric beds and bassinets, respectively. The analysis also shows that high-risk mothers value the characteristics of Neonate Intensive Care Unit hospitals. A high-risk pregnant mother is a mother that is below 17 years old, or that is 35 and older and have had at least one previous c-section, or that is 44 years and older, or that has a plural birth (e.g., twins, triplets) and have had at least one previous c-section, or that has at least one pre-pregnancy risk factors such as diabetes, chronic hypertension, and eclampsia (Mayo-Clinic (2020)). High-risk mothers are willing to travel an additional 3.08 miles to go to a NICU hospital, which represents an extra 9.5% of the average distance traveled by those mothers. The high-risk mother heterogeneity analysis shows that the willingness to travel additional mileage for NICU hospitals is 3.93 miles for other-race (e.g., Asian), 3.66 miles for blacks, 3.09 miles for whites, and 1.24 miles for Hispanics. In particular, high-risk mothers below 21 years are willing to travel an extra 10.4 miles (or 32% more miles) to go to NICU hospitals. Given that these hospitals have advanced technology and trained specialists to take care of the newborn, the choice of NICU hospitals by a high-risk mother may represent a contingency plan for those mothers in the advent of a difficult birth.

The results also suggest that rural mothers are less likely to select University-affiliated institutions for delivery purposes. There are several possible explanations for this finding. First, very few rural providers can admit patients in teaching hospitals, which reduces the likelihood that rural patients will choose Academic Medical Centers for delivery. Second, patients who expect a smooth delivery process are less likely to choose those hospitals since they are associated with additional transportation costs, more opportunity cost of time, and additional discomfort for a pregnant mother. Third, some patients are less likely to choose teaching hospitals because they are afraid that the attending physician may be a resident and not a senior doctor (Mishori, 2003).

Furthermore, the results show that rural mothers value hospitals accredited by the Joint Commission, which is the reference in terms of hospital quality and safety standards. Regarding hospital ownership, rural mothers value the characteristics of both public and non-public hospitals more than they value private for-profit hospitals. This is likely to be because those institutions are relatively cheaper than private for-profit institutions. The results are robust to several specification checks such as mother heterogeneity analysis, a control group design, and choice set expansion and contraction. Overall, the study concludes that rural patients dislike going to hospitals that are further away and value quality care.

The results are consistent with the random utility theory, which posits that mothers will choose the hospital that maximizes their satisfaction considering traveled distance and hospital quality. This paper makes several contributions to the literature. One particular strength of the paper is combining two large datasets, such as the universe of birth records in the United States and the near-universe of hospitals. We exploit these large datasets to evaluate the quality-distance tradeoff for the US rural mothers, a population not studied previously. The quasi totality of the studies that investigate this tradeoff is either state-specific (Luft et al. (1990), Premkumar et al. (2016)) or use Medicare patients (Adams et al. (1991), Tay (2003)). Our main limitation comes from the Vital Statistics data that only reports the county of birth and not the birth hospital. To our knowledge, we are the first to develop a probabilistic approach that turns around this issue to evaluate the tradeoff between distance traveled and hospital quality.

In a context of obstetric care shortages and hospital closures, access to care becomes really important for policy perspective. The study helps think about tradeoff for policy perspective, especially by evaluating the willingness to travel additional miles for better quality for different sub-groups of the population. In that sense, the paper helps knowing who is harmed and benefited from policy interventions to subsidize, open, or close various types of health facilities, including NICU, teaching, public, private, critical access, and sole community hospitals. Our results are directly relevant to policy debates on 1) the necessity to invest in the expansion of health care facilities in rural areas and 2) the necessity to invest in improving the quality of care provided in rural communities, both of which pertain to Certificate of Need Laws (CON Laws). These policy recommendations can have tremendous impacts on the 18 million women of reproductive age living in rural areas.

The remainder of the study is organized in this order. Section II presents the literature review, section III covers the conceptual framework, section IV describes the data sources. Last, sections V to VIII exhibit respectively the model specification, the empirical results, the robustness checks, and a discussion of the findings.

2 Literature review

2.1 Hospital Choice Process

Understanding patients' hospital choice requires at least some comprehension of individuals' decision to seek care in the first place. Andersen et al. (1968) lays the underpinning of individual behavioral processes underlying the hospital choice model. While the Andersen model is not directly related to hospital choice, it displays a suitable mechanism of an individual decision to seek care. Andersen et al. (1968) prescribes the following three sets of determining factors to a person's decision to seek medical care: 1) medical needs factors such as the perceived health status of an individual, the nature of his/ her medical conditions; 2) predisposing factors (age, education, and race) that affect an individual's marginal tendency toward seeking medical care; and 3) enabling factors to determine individual access to care such as income, insurance coverage, physicians' access, etc... As for choosing a specific hospital, Porell and Adams (1995) argues that there is little consensus regarding the step-by-step process of individuals choosing a particular hospital.

In general, a patient chooses a doctor that has admitting privileges in a given hospital, and considering the person's insurance, the doctor decides on which hospital to treat the patient. In some cases, the treating physician may have affiliations to several hospitals. Garnick et al. (1987) and Luft et al. (1990) argue that diagnosing physicians dominate the hospital selection decision for patients, while studies by McGuirk and Porell (1984) and Morrisey et al.

(1988) assert that patients play the critical role in terms of hospital selection after evaluating distance travel, perceived quality of the hospital, as well as physicians affiliations to specific hospitals. To this, Porell and Adams (1995) adds it doesn't matter whether patients or physicians make the decision. As long as the relative preferences are expressed in terms of hospital characteristics, quality, and price, the relative preferences should be reflected in systematic hospital choice patterns.

The hospital choice is often made one or several months before childbirth. And, in most cases, childbirth is a non-emergency care where a mother, her physician, and her lay network (family and friends) prepare for the birth event. In these cases, the mother delivers the baby in a hospital that was already chosen by the physician considering the patient's insurance (or the partner's insurance), the patient's preferences, and the physician's preferences and hospitals' affiliations. But, in some cases labor can be unexpected, which may constrain women choices regarding the hospital they deliver at. Under the Emergency Medical Treatment & Labor Act, signed by Congress in 1986, hospitals are required to provide emergency care to patients regardless of their ability to pay. So, in emergency situations, the mother is likely to go to the nearest hospital.

2.2 Hospital Choice and Distance

The earliest strand of the hospital choice literature was heavily focused on distance decay, which emphasizes that more considerable distances tend to decrease hospital utilization. The "distance decay" literature is also in line with the first law of geography, according to which near things have more association than things that are remotely dispersed. In general, the model fitted to assess the spatial patterns in hospital utilization is a form of a negative exponential function of distance (Morrill and Earickson (1968), Morrill et al. (1970)). An essential finding of this literature is that distance-utilization elasticity is much lower for larger hospitals than smaller hospitals.

Other studies in this literature performed a spatial analysis model used in geography and social physics to predict the flows of hospital admissions based on the economic sizes and distance between the community of residence and hospital localization. Known as the gravity model, the latter is similar to the Newtonian gravity model. Its hypothesis postulates that the greater the distance between two points in space, the lesser the spatial interaction between these points. Specifically, the social gravity model is expressed as follows: $I_{ij} = \frac{G_i H_j}{F_{ij}}$, where I_{ij} represents the count of patients from community i going to hospital j; G_i accounts for the population mass of the gravity model often labeled in terms of the population size of the place of residence; H_j represents the capacity of hospital j, and F_{ij} accounts for frictional force or patient travel time. Roghmann and Zastowny (1979) considers F_{ij} as the distance of patient i to the nearest and next-nearest hospital in community j. As such, the gravity model postulates that the number of patients flowing from community i to hospital j is a negative function of the distance travel.

Another group of studies in the hospital choice literature uses the McFadden (1974) conditional logit model or some other forms of Random Utility Model (RUM). Specifically, the conditional logit choice model is expressed as follows: $P_{ih} = \frac{exp(U(X_i, H_h)}{\sum_{h=0}^{H} exp(U(X_i, H_h))}$, where P_{ih} symbolizes the probability that patient i chooses hospital h, $U(X_i, H_h)$ represents a linear function of individual characteristics such as age, race, gender, etc. and features of different hospital alternatives. In general, this literature considers distance as a disamenity or a cost factor which brings dis-utility to the individuals (Luft et al. (1990), Tay (2003), Chandra et al. (2016)). The negative effect of distance on demand is large (Tay (2003)) and it is associated with a significant reduction in the likelihood that a hospital will be chosen. Other non-RUM studies find that increased travel time is associated with reductions in the likelihood of having a checkup by minority children (Currie and Reagan, 2003) while Buchmueller et al. (2006) find that increased distance to the nearest hospital is associated with higher mortality and injuries.

Overall, conventional wisdom, as established by the distance decay approach, gravity model, and Random Utility Models, supports the idea of a strong negative relationship between patient distance traveled and hospital choice. Simply put, distance plays a significant role in the hospital selection process of a patient.

2.3 Hospital Choice and Hospital Quality

The literature on hospital quality and quality of care shows that there is a multitude of possible dimensions and criteria to define hospital quality and quality of medical care. A seminal paper, Donabedian (1966), like Lee (1933), defines quality as value judgments to the several aspects and dimensions of a process called medical care. Another early and influential study, Klein et al. (1961), argues that the notion of patient care is not a unitary concept and that there will always be an array of criteria to measure the quality of patient care. Even more recently, Chandra et al. (2016) supports the notion that hospital quality is a multi-dimensional object that is a combination of hospitals' ability to produce good health outcomes, patients' beliefs regarding hospitals' ability to produce good health outcomes, and patients' satisfaction from past experiences. As such, conventional wisdom regards hospital quality as a non-unitary, elusive, and multi-dimensional concept along the spectrum of time.

A hospital is an economic agent with a production function and uses several inputs such as equipment, beds, nurses and doctors, and other factors to produce medical and surgical treatment. The hospital quality literature review suggests that studies generally either use an input or an output approach, which, by and large, implies a distinction between means and ends. Although economically speaking, the input comes typically first, the hospital quality and medical care quality literature in its earlier strand focused more on medical care outcomes to assess hospital quality. Previous studies have considered outcomes such as perinatal mortality (NYAM (1955); Shapiro et al. (1960)), surgical fatality rates (Lipworth et al., 1963). More recent studies in their assessment of the quality of care also relied on outcomes such as risk-adjusted 30-day survival rates (Chandra et al., 2016), risk-adjusted readmission rates as a proxy for medical errors and inappropriate discharge (Chandra et al. (2016); Jencks et al. (2009), Axon and Williams (2011)), severity-adjusted mortality and complication rates (Luft et al., 1990).

Given that the quality measures have not been standardized and mostly were not used nationally, several organizations such as the Centers for Medicare and Medicaid Services (CMS), the American Hospital Association, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), and many other partners have joined their forces to create the Hospital Quality Alliance (HQA). Under this joint effort, hospital facilities accept to provide CMS indicators of quality of care on several conditions such as acute myocardial infarction, congestive heart failure, and pneumonia (Jha et al., 2005). Since November 2004, when HQA data became available, many studies have analyzed patient's perceptions of hospital care. Jha et al. (2007) uses Medicare enrollees admitted for acute myocardial infarction, congestive heart failure, and pneumonia to evaluate their relationship with the HQA indicators of performance. The study concludes to the validity of the HQA indicators in the sense that higher performance on the HQA measures was associated with lower risk-adjusted mortality for the three conditions, which represent over 15% of Medicare hospital medical and surgical admissions.

Although the outcomes (output approach) considered in the literature are relatively concrete metrics, Donabedian (1966) argues that there are many drawbacks to using outcomes as a dimension of quality of care. The first inconvenient is whether the outcome utilized is the relevant measure. A scenario where the criterion to assess medical care is survival rate in a non-fatal situation is an example. The study further argues that even in a context where the outcomes chosen to evaluate hospital quality are relevant, several other limitations must be reckoned with: First, other medical service determinants may affect the outcome. Second, sometimes it may take more than decades before relevant effects are present. Thirdly, sometimes, medical care measures are not clearly defined and can be difficult metrics to use. The study suggests that criteria such as patient attitudes and satisfactions, and social rehabilitation are some examples.

Furthermore, Tay (2003) argues that there are several problems with patient outcomes as quality indicators. Patient outcomes are noisy, especially for low-patient volume hospitals. There may also be a selection bias problem where individual hospitals attract the patients with the worse health outcomes. Patients tend to sort hospitals as a function of the severity of their illnesses. As such, the bias dimension is heterogeneous in the severity of the disease, with severely ill patients seeking hospitals that provide more intensive treatments. Tay (2002) also suggests that this bias may lead to systematic differences in patient health outcomes across hospitals. That being the case if lower quality rural hospitals only attract and admit less ill and low-risk patients, the quality of care they actually produce is likely to be lower than that implied by the average mortality or readmission rates of their patients. Tay (2002) suggests one way to solve this problem is to use a behavioral hospital choice model to overcome the selection problem.

Besides the output approach, the literature refers to the process of care and the setting in which it takes place as other assessment methods of medical care and hospital quality (Donabedian, 1966). This approach considers the structure, administrative processes, adequacy of facilities and equipment, the personal and medical staff's competence level, etc. By and large, this framework relies on the hypothesis that if a hospital operates under the proper settings and instrumentalities, the provision of quality care will be automatic. Donabedian

(1966) argues that one limitation of this approach is that the association between structure and process or structure and outcome is not clearly established.

2.4 Quality Metrics Used In This Paper

To estimate the tradeoff between hospital quality and distance, we use several quality metrics. In general, those quality measures are related to the settings and instrumentalities associated with the provision of quality care.

Our first quality metric is a dummy variable that captures whether a potential hospital of birth provides Neonate Intensive Care Unit (NICU) care. Given the possibility of unexpected factors such as prematurity[1], Respiratory Distress Syndrome (RDS) [2], infection[3], hypoglycemia[4], maternal chorioamnionitis [5], and even re-admission, expectant mothers generally value hospital that also provides intensive care services. For infants born in a non-NICU setting, when there is an emergency that requires the skills and specificities of a NICU, the newborns are transferred to a NICU. Hence, there may be potential additional stress for the mothers related to the process of moving the child to a hospital with NICU. As such, the existence of a NICU in a hospital facility may change patient's perceptions regarding the hospital's ability to produce good pregnancy and neonatal care. Existing literature suggests that parents value a NICU's presence in a health facility (Cleveland, 2008).

Our second quality measure accounts separately for the number of obstetric beds and bassinets (beds for babies) in a potential hospital of birth. This metric is a proxy for the health facility's size, which is generally perceived as a signal of quality by patients (Boscarino, 1988).

[1]Prematurity is when the baby is born too early (less than 37 weeks of gestation).

[2]RDS is a prevalent respiration issue in babies that is due to immature lungs. Oxygen machines, breathing tubes, or ventilators are generally needed to help infants overcome this respiratory problem.

[3]Infection or sepsis is a widespread cause of neonatal death.

[4]low blood sugar level

[5]maternal inflammation of the placenta or the umbilical cord that increases the risk of the baby to have an infection.

Our third quality measure is an indicator for whether a potential hospital of birth receives an accreditation from the Joint Commission[6]. In general, Medicare-participating hospitals need to follow a set of Conditions of Participation (CoP) rules, which guarantee a minimum safety level. Under the CoPs, the requirements are authenticated through accreditation and certification (Moffett et al. (2005)). But, specifically, for non-emergency care such as childbirth, where a mother and her lay network (family and friends) tend to do online shopping for a hospital to deliver[7], it is likely that an accredited hospital will be perceived as a signal of good quality by expectant mothers. Besides, if the choice was made by a physician that has admitting privileges in a given hospital, it is also likely that this facility is accredited.

Finally, the fourth quality measure captures patients' valuation of teaching hospitals. These facilities have the reputation of highly specialized (Levin et al., 2000) and high-quality care (Boscarino, 1992). They also tend to use cutting-edge technology to do state-of-the-art research to develop new treatments and cures. They have a wide range of interns and residents and are generally affiliated with a medical school, which can also increase patients' perception about their ability to provide good health outcomes. Consequently, high-income rural patients are likely to value them as producers of good quality medical care when choosing.

The four measures of quality considered in this study capture different aspects of quality of care. In general, they represent a mixture of a hospital setting and its ability to produce good medical services and are likely to influence patient's beliefs about hospitals' capabilities to have good health outcomes.

[6]Founded in 1951, the Joint commission is the oldest and the reference in terms of hospital quality and safety standards. The accreditation is not necessarily specific to maternity care.

[7]Anhang Price et al. (2014) provides suggestive evidence that patients consult hospital rankings a year before their visits.

3 Conceptual Framework

This section presents a basic utility framework that relies on the Maximum Utility Theory and the idea that the expectant mother chooses the hospital for delivery to maximize utility. Each patient faces a choice among $h = 1, 2, ..., H$ hospital alternatives and derives satisfaction from the medical care received from each possible hospital choice. A mother may have perceptions about the quality of a hospital, attitudes regarding the importance of the quality, preferences among specific hospital alternatives, and a protocol to maximize preferences considering the direct out-of-pocket transportation costs and the opportunity cost of travel time (McFadden, 1986). Specifically, the model is built under the following assumptions:

1. Expectant mothers are assumed to try to get the most value from their resources.
2. Expectant mothers' incomes are limited. They face a budget constraint[8].
3. A mother's choice set is made of several hospital alternatives.
4. Mothers form beliefs about the quality of care that they are likely to receive in each possible hospital alternatives.
5. Mothers are aware of the distance in miles to travel from their residence to a given hospital choice.
6. Mothers have clear preferences over various hospital alternatives and will choose the one that maximizes their satisfaction.
7. Whether the mother or a referring physician chooses the hospital for the patient does not really matter[9].

[8]The money constraint may not be significant for most rural mothers because Medicaid/CHIP covers births for women up to some high-income levels depending on the state and its Medicaid expansion status. Also, emergency Medicaid pays for labor and delivery for non-citizens who do not otherwise qualify for Medicaid.

[9]Almost all papers in the hospital choice literature make this assumption. Porell and Adams (1995) adds it doesn't matter whether patients or physicians make the decision. As long as the relative preferences are expressed in terms of hospital characteristics, quality, and price, the relative preferences should be reflected in systematic hospital choice patterns.

8. A mother's place of residence is exogenous.

Given that every obstetric service provided by the chosen hospital has a price tag which depends on the insurance network, expectant mothers select the hospital that maximizes their expected utility across all alternatives considering their limited incomes. In general, patients formulate their demand for obstetrics care from a given hospital h based on their characteristics such as medical needs, perceived health status, predisposing factors (age, education, race, etc.), and enabling factors (income, insurance coverage, etc.).
A patient's utility can be expressed as follows:

$$U_{ih} = V_{ih}(distance_{ih}, quality_h),$$

with i being the patient and h a particular alternative. The marginal utilities will depend on the functional form chosen to represent the mothers' preferences. As such, any monotonic transformation of the utility is also going to affect the marginal utilities and its interpretation. For a more consistent interpretation, we will refer to the ratio of marginal utilities. For example, if we consider a change in the health care consumption bundle ($\Delta distance_{ih}$,$\Delta quality_h$) such that the mother is kept at the same indifference curve, we must have:

$$\Delta U distance_{ih} + \Delta U quality_h = \Delta U$$

$\Rightarrow$

$$MU distance_{ih} * \Delta distance_{ih} + MU quality_h * \Delta quality_h = 0$$

$\Rightarrow$ which is equivalent to:

$$MRS = \frac{\Delta quality_h}{\Delta distance_{ih}} = -\frac{MU distance_{ih}}{MU quality_h}.$$

The ratio of the two marginal utilities is the Marginal Rate of Substitution (MRS) between quality and distance. It represents the combinations of distance and quality that provide the mother the same level of satisfaction. It measures the rate at which the mother is willing to substitute distance for quality. Because the mother is on the same indifference curve (Figure 1), the dis-utility resulting from an increase in distance traveled is exactly offset by the utility resulting from an increase in quality. For example, in the case of obstetric beds as an indicator of quality, if the MRS=-2, the mother will be willing to give up 2 miles of distance for every 1 additional obstetric bed. Besides, we assume that minority, low-education, low risks level are less likely to be willing to tradeoff distance for quality because their hospital decision process is more likely to be driven by the distance to the hospital, its related out-of-pocket transportation, and additional discomfort associated with more travel time.

The conceptual framework yields the following testable predictions:

1) **On average, mothers dislike hospitals that are further away.**

2) **On average, mothers prefer hospitals with better quality.**

3) **On average, minority, older, low-educated, and low-risk level mothers face relatively lower tradeoffs than their peers.**

4 Data

4.1 Data Sources and Manipulation

To evaluate the tradeoff between hospital quality and distance, we use the following two data sources: the 2007-2017 U.S. Linked live birth and infant death certificates data and the 2007-2017 American Hospital Association (AHA) Annual Survey data. Besides, to compute the distance[10] measures, we obtain latitude and longitude coordinates for residential and birth

[10]We use great-circle distances or spherical distances, which characterize the shortest distance between two points (the centroid of the county of residence and a potential birth occurrence county). The distance metrics are calculated using the haversine law and are correct to within about 0.5%(NAVY, 1987). Ideally, we would want to use the actual distance traveled by the patient. Due to data limitation, we use this spherical distance measure as a proxy.

occurrence counties from different commercially available geographic files. We identify rural mothers using county FIPS codes and the definition adopted by the Office of Management and Budget (OMB). For rural counties, we consider the 2013 Rural-Urban Continuum Codes of four or more [11].

We make use of the natality and period linked birth-infant-death data from the National Center for Health Statistics for mothers' information. This is an administrative data set that provides birth certificates for all births in the United States and linked death records for all deaths that occurred within the first year of life. It is the best available source of information for a national study on a mother's birthplace analysis and is widely utilized in the maternal and infant health literature. While the dataset identifies the county of residence and birth occurrence[12], the restricted version of the data that we use does not have mothers' and hospitals' addresses. Given that the natality data doesn't provide information about the hospital of birth, we use the American Hospital Association (AHA) annual surveys to link the mothers to a potential hospital[13]. The AHA is a survey of the complete universe of U.S. hospitals with a 80% response rate. For non-responding hospitals[14], the AHA uses an estimation process to impute missing statistical values. This survey represents one of the most comprehensive and credible sources of information about hospital facilities and is widely used in the hospital literature. This data provides the complete address of nearly all hospitals in the U.S. (whether they answer the survey for a particular year or not).

[11] The 2013 Rural-Urban Continuum Codes use the degree of urbanization and adjacency to a metro area to classify nonmetropolitan counties (Economic Research Service, U.S Department of Agriculture). The official classification scheme is made of three metro and six non-metro categories.

[12] For about 30% of women, the county of residence and birth occurrence is different. There are mainly three reasons why this may be the case. First, it may be that the county of living has never had a hospital, whether providing obstetric care or not (March of Dimes (2018)). Second, it may also be the case that the county of residence had one or several hospitals closed during the birth occurrence period. Finally, it may happen that the women decided to bypass their county hospital to go to another county hospital, as it is often the case in rural areas (White and Morrisey, 1998).

[13] In rural areas, over the study period, there are 98% hospital births, 1.5% home births, and 0.50% births coming from freestanding birth center. So, a non-hospital birth is a rare event. We only keep the hospital births.

[14] Some responding hospitals have missing values for some of our indicators. See appendix for more details about how we deal with those missing values.

Besides the natality and AHA data, we create a separate dataset that enables us to identify all the counties that are within a radius of 50 miles of each specific county. A "ghost" county was also created for all the counties outside of the 50 miles defined market area. This small dataset was then merged with the natality files using the county of residence. Upon merging, for each individual, we are able to observe all the potential counties where the individual could give birth (within the 50 miles radius + outside the radius through the ghost county). We can identify the actual county of birth of occurrence from the natality data, along with the other potential counties where the birth could have occurred. We use 50 miles as our defined market area for the hospital choice framework after several considerations such as distance traveled distributions, and Federal Regulations[15] related to the establishment of community hospitals such as Sole Community Hospital (SCH) and Critical Access Hospital (CAH). Below, we also use several other market areas to corroborate our results. The data shows that traveling across the entire country to give birth is a rare event[16].

As said earlier, for each mother, we are able to identify all the potential counties where she could give birth, including the actual county of birth occurrence and the "ghost" county, which allows us to close the choice set for each mother. We then merge this data to the near universe of hospitals in the United States [17]. For the "ghost" county, we create a single

[15]Critical Access Hospitals are created through the Balance Budget Act of 1997. They must be located more than 35 miles from another hospital. According to the Title 42 of the 1983 Federal Regulations, a Sole Community Hospital (SCH) must be about 50 miles away from other hospitals.

[16]We understand that a mother may go even beyond 1,000 miles if she has a condition that requires a specialist from a faraway county. Only 6.7% of the mothers in the dataset go outside of the defined market area of 50 miles to deliver their babies. Some expectant mothers may pick a hospital in a faraway county to deliver because 1) they don't like the characteristics of the hospitals in the market designated area; 2) they have a condition that requires them to see a specialist that maybe even 1000 miles away, or 3) because of some other strange reasons. Several papers in the literature (Luft et al. (1990), Tay (2003), Moscelli et al. (2016)) drop all the individuals in their sample who shopped outside of their defined market areas.

[17]We merge with all types of hospitals and not only obstetric units. One could also suggest using observed demand patterns to create the choice set. One way to do the observed demand patterns approach is to find a benchmark in the literature or limit the choice set to hospitals where, say, at least ten births occurred last year. The demand pattern approach has a built-in selection problem. Maybe, the other places with zero births were not chosen for delivery because they have low quality. Indeed, some of those places may not have obstetric units, but there is significant evidence of births in other places with no obstetric units. As such,

"ghost" hospital to which we impute [18] the average hospital characteristics and differentiate it with a dummy variable indicating if it is more than 50 miles from the county of residence. We yield a total of 113,488,826 birth-hospital matched observations, for a total of 6,039,936 rural-residing mothers who gave birth between the period 2007 and 2017. The average number of hospitals in each mother's choice set is 18 (See Figure 2, for more information about the distribution of hospitals in the county of childbirth). Although we only select rural mothers for whom the tradeoff between distance and quality is arguably a more interesting phenomenon, they could give birth in any urban county considering the 50 miles and how close they live to a metropolitan area.

To evaluate the tradeoff of interest, we employ great-circle or spherical distances. This acts as a proxy for road distance or actual travel times. We use the AHA survey data to create several hospital quality indicators (See Appendix for details about how we deal with missing values). We utilize the number of obstetric beds and the number of bassinets (sleeping baby's beds) in a given hospital. We also consider a dummy variable that takes one if a given hospital has at least one Neonate Intensive Care Unit (NICU) bed and zero otherwise. Empirical evidence shows that mothers value NICU because of the possibility of taking care of the baby in case of early delivery, health problems, or the possibility of a difficult birth (Conner and Nelson, 1999). We use dummy variables to identify teaching status, and an indicator that controls for any accreditation received by a given hospital. These multiple aspects of hospital quality will enable us to assess which quality factors mothers value when considering a hospital for delivery. The multiple aspects of hospital quality used in this paper are mostly related to the patient's perceptions of the hospital quality. These factors are likely to play a significant role in the patient's choice of a hospital. In that regard, Chandra et al. (2016) argues that hospital quality is a multidimensional object that is a combination

the distance-based approach is better. At least, it solves the selection problem by including all hospitals within a given area, whether good or bad.

[18] Imputing the average in-state hospital characteristics changes very little.

of hospital capacity to produce good health outcomes, patients' beliefs about hospital ability to have good health outcomes, and patients' satisfaction from past experiences. Sixma et al. (1998) suggests that hospital quality, as seen through the patient's eyes, is of paramount importance in hospital choice.

One important limitation of this study comes from the Vital Statistics data that only reports the county of birth, and not the hospital of birth. A simple conditional logit (fixed-effect logit model) would suffice to estimate the model if the chosen hospital was known. Given the absence of this information, we exploit a maximum likelihood estimation framework that aggregates the probability of choosing any hospital within a county as the sum of the probabilities of choosing each hospital within the county. Many rural counties have only one hospital, and for mothers choosing such a county the probability of that county is exactly a conditional logit formulation.

4.2 Descriptive Statistics

Table 1 below presents the descriptive statistics. Over the sample period 2007-2017, the study sample has 113,488,826 birth-hospital observations for a total of 6,039,936 rural mothers and an average of 18 hospitals per individual located within 50 miles of the centroid of the county of residence. Only 6.7% of the mothers go beyond the 50 miles to deliver their babies, with the majority being white. Half of the rural mothers are between 25 and 34 years, 70% are white, 57% of those mothers are married, 62% of them have more than one child, and 50% of them have more than a high school degree. The average distance between the centroid of the county of residence and a potential county of birth is 32.24 miles. The average number of obstetric beds is about 8 beds and 8.2 bassinets (beds for babies). Over the period, 12% of all the hospitals have at least one neonate intensive care unit bed, and 66% of them are accredited by the Joint Commission. Only 2.4% of those health facilities are major teaching hospitals, while 18% are minor teaching hospitals. About half of them are non-profit hospitals, and 23% of them are public hospitals. A large portion of the hospital facilities over the sample period have relatively small beds, including 19% critical access hospitals and only 4.8% Sole Community Hospitals. The average hospital has 40 maternity care providers with admitting privileges and 194 registered nurses.

5 Empirical Specification

To estimate the tradeoff between hospital quality and distance faced by US rural mothers, we use a mother-hospital probabilistic choice model rooted in the Maximum Utility Theory. This approach provides a theoretical justification and the solid empirical ground needed to estimate the model and offer some insights into the role of care quality and distance in the mother's hospital choice.

5.1 Model specification

The empirical analysis is based on the Random Utility Theory, which treats some aspects of individual preferences unobservable to the researcher as random. The model is estimated using a maximum likelihood approach. Specifically, the utility of choosing a particular hospital for delivery is modeled as:

$$U_{iht} = V_{iht} + \varepsilon_{iht} \quad (1)$$

with

$$V_{iht} = W_{iht}\alpha + Z_{it} * \delta_{ht} + \gamma_{ht} + \lambda_{sct}$$

where $i = 1, ..., N$ is the rural expectant mother, with N being the total number of mothers; $h = 1, ..., H_{it}$ is the hospital where patient i could deliver the baby, with H_{it} being the total number of hospital alternatives in the mother's choice set; and t being the birth year. Additionally, the V_{iht} (explained component of the utility) captures the desirability of hospital alternatives. These utilities are a linear function of hospital-specific attributes (distance and quality metrics), interaction terms between hospital features and individual characteristics, interactions between individual factors and some features of the choice set (bypass phenomenon, going beyond the defined market area), and community features. Given that this approach is a within-individual framework, all factors that do not vary within individuals across hospitals will not impact the choice of hospital. We do allow some individual-specific variables such as age, education, and marital status to interact with hospital attributes. The γ_{ht} component captures hospital characteristics such as different indicators for total hospital beds, outpatient visits, hospital personnels, number of registered nurses adjusted by the state scope of practice laws, number of maternity care providers with admitting privileges, and hospital total expenses. The interaction terms are used to capture observable heterogeneity in the estimated coefficients.

Besides, the λ_{sct} component captures several community features such as hospitals in Medicaid expansion state, obstetric reimbursement rates, certificates of needs law, poverty rates, county household income, unemployment rate, and county population. These impacts are identified by variations in the choice sets that overlap several counties and states. For example, the choice set for mothers living in a state with Medicaid expansion could include hospitals located in another state that did not expand Medicaid. This random utility model has a compensatory or tradeoff interpretation between the different explanatory variables. Luft et al. (1990) argues that one major advantage of this type of qualitative choice modeling is that it considers the characteristics of the alternatives rejected and the chosen one in computing parameter estimates.

The unobserved random error term, ε_{iht}, captures disturbances from unmeasured attitudes and preference variations that are independently and identically distributed according to a type I extreme value distribution. In this framework, a mother will choose an alternative

j if it provides the highest utility. The probability of individual i choosing a hospital j in county c is given by:

$$P_{ijt} = P(U_{ijt} > U_{ilt}) = \frac{\sum_{j \in C} exp(V_{ijt})}{\sum_{h=1}^{H_{it}} exp(V_{iht})}, \forall \ \ l \in H_{it},$$

where the summation in the numerator is the sum over all hospitals within county c. The log-likelihood is maximized numerically given hospital-specific attributes, individual-specific characteristics, choice set features, several interaction terms, and community amenities.

5.2 Other Independent Variables

Critical Access Hospitals (CAH)

The Centers for Medicare and Medicaid Services designate Medicare-participating hospital facilities as Critical Access Hospitals if they meet specific criteria, such as being located in a rural area of either more than 35-miles from the nearest hospital, reporting no more than 25 beds (either inpatient or swing beds), maintaining an average length of stay of 96 hours or less for acute care patients, and providing 24/7 emergency services. Those hospitals account for two-thirds of all rural hospitals and maybe the first access to care for many rural areas mothers. As such, we control for critical access in the model. Although they may not be well-equipped with high-level technological materials, given their nearness, patients' network perceptions, the possibility of 24/7 emergency care, they may be well-valued by mothers.

Sole Community Hospitals (SCH)

In 1983, Congress created the SCH program to bolster rural hospitals and provide care to individuals living in very remote areas where travel, weather conditions, and the absence of health facilities may represent a significant barrier to access care. According to the Title 42 of the 1983 Federal Regulations, to be designated as SCH, a hospital must either be more than

50 miles away from other hospitals or less than 50 miles but was not accessible to patients due to some topographical or weather conditions for an extended period. Since topography is not uniformly distributed in the country, Sole Community Hospitals may represent the unique source of care that some mothers can acquire at a reasonable distance.

Public Hospitals (PH)

Public hospitals are grouped into Federal (e.g., Navy Hospital) and non-Federal Hospitals (e.g., state Hospital, Hospital district). Because those health facilities are generally either partly or fully funded by public funds, they accept nearly everyone, regardless of insurance status. While public hospitals are usually more affordable and larger, private or for-profit hospitals tend to provide more personalized care due to doctors and nurses overseeing fewer patients per person. Hence, we expect mothers with restrictive insurance coverage and low purchasing power to value public hospitals more. Higher-income patients and those with high valuations for short waiting periods are expected to prefer private hospitals.

Non-Profit Hospitals

Non-Profit Hospitals are charity institutions that do not pay taxes in exchange for meaningful contributions to their communities. They are generally cheaper than investor-owned for-profit institutions. About 50% of US hospitals are non-profit institutions. We expect patients with low purchasing power to value the characteristics of non-profit hospitals.

5.3 Endogeneity

The model's central assumption is that distance and the observed quality measures are uncorrelated with the error term, meaning that they are exogenous. Endogeneity of the distance variable would mean that mothers self-select their place of residence due to obstetric care providers in a community. While there is significant evidence of mothers' location decision for school quality (Liu et al. (2010)), to our knowledge, no study suggests that mothers sort communities of residence due to obstetric care. As a result, we argue that distance from a county of residence to a potential county of birth is exogenous.

Regarding the possible endogeneity of hospital quality, the literature takes different positions, including 1) not discussing it (Luft et al. 1990); 2) discussing it and assuming that it is exogenous (Tay 2003) [19], and 3) treating it as endogenous and using hospital fixed-effects among other approaches (Gutacker et al. (2016)). The possible endogeneity of the hospital quality measures would mean that there are unobserved hospital factors that are correlated with at least one of the quality metrics and that affect hospital choice. In the appendix, we present a lagged quality [20] measures model to examine whether recent changes in quality measures might be related to the unobserved components (Gutacker et al., 2016)

It may also be that there is a systematic selection pattern where sicker patients select better quality hospitals. Tay (2002) argues that this systematic patient selection bias is more of a problem for studies that use hospital outcomes (mortality rates, readmission rates, etc.) as quality indicators. If lower-quality rural hospitals only attract and admit less ill and low-risk patients, the quality of care they actually produce is likely to be lower than that implied by their patients' average mortality or readmission rates. As noted above, the quality metrics used in this study are related to the settings and instrumentalities associated with quality care provision. Also, provider quality metrics are adjusted by a large set of demographic and community characteristics. Consequently, unobserved patient selection should not bias our results substantially.

[19] Tay (2003) even argues that to her knowledge no other study has addressed the endogeneity aspect of quality choice of hospital.

[20] Here, demand reacts to past hospital quality values, but past indicators of quality cannot be affected by demand today. Additionally, demand may influence the provision of obstetric beds, bassinets beds, NICU beds, etc. Due to hospital short-run capacity constraints, an increase in demand may even cause some beds' re-allocation into obstetric beds. This would also lead to potential simultaneity bias, where choice affects quality and quality influences choice. Although the short-run capacity constraint is also less relevant for our individual choice model, we believe that the use of a lag-quality model may solve this potential problem

A hospital fixed-effect approach could remove possible unobserved time-invariant hospital characteristics such as hospital culture and attitudes toward quality care. It would capture each hospital's time-invariant features as the between-hospital variations would be eliminated. As such, the model would be identified of within-hospital variations over time. There is a key one problem with this approach: there is very low within-provider variations over time and much of these variations could reflect simple measurement issues. To investigate the possibility of low within-provider variations, we compute the Intraclass Correlation Coefficient (ICC) for the quality metrics. Intraclass Correlation Coefficients (ICC) account for the total amount of variance attributable to between-unit rather than within-unit differences over time (Hausknecht et al., 2008). The between-provider variations range between 94% and 98% for the quality metrics; all of these variations will be discarded by the inclusion of hospital fixed effects, which would induce very low within variations in the hospital quality metrics. These low within-providers variations are consistent with Tay (2003)'s idea, according to which a health facility may take several years to adjust quality. Furthermore, Gutacker et al. (2016) argues that minimal within-provider variations such as these are likely to obstruct the identification of a hospital fixed-effect model and that this model could yield very large standard errors for the estimates of the marginal utility of quality.

5.4 Results' Interpretation

The model estimates marginal utility for traveled distance and different hospital quality measures. The marginal utility represents the net utility from the change in a given factor. For example, the point estimates for private for-profit hospitals represent the net utility from comparing private for-profit to non-private for-profit hospitals. A negative marginal utility [21] for private for-profit hospitals means that patients do not value the characteristics of private for-profit hospitals relative to non-private for-profit hospitals. It may be that the patients like the quality of the services provided by private for-profit hospitals but dislike the cost

[21] The utility function (1) is unique up to a linear transformation. Any monotonic transformation will affect the marginal utility. A more consistent measure is the ratio of marginal utilities.

of those facilities relatively more than non-private for-profit. As such, even if patients have private for-profit hospitals in their choice set, they are less likely to go to those facilities. On the other hand, if the marginal utility for private for-profit hospitals is positive, patients would be more likely to go to those facilities if they have them in their choice set.

This paper uses different observable heterogeneity models. Considering that coefficients in separate Multinomial Logit Model may be scaled differently, we use an interpretation consistent for all the models. We compute the willingness to travel (WTT) for a unit change in a given quality measure m by the following formula: $WTT_m = (-\frac{MUquality_{ht}}{MUdistance_{iht}})$ as in Moscelli et al. (2016) and Gutacker et al. (2016). WTT_m is the change in distance that a rural mother requires to offset a one unit increase in a given quality measure m. It represents the additional miles a given mother would be willing to travel to a hospital of higher quality.

6 Empirical Results and Discussions

6.1 Main Effects

Table 2 reports the results for the main specification, where the main effects are estimates of marginal utilities for a given factor. The estimates show that rural mothers have negative marginal utilities for distance. Mothers also expressed negative valuations for counties that are outside of the 50-miles radius from their county of residence. This result makes sense because higher distances are synonym of higher out-of-pocket transportation costs and more significant discomfort for a pregnant mother. The finding is also consistent with studies using different approaches such as distance decay, gravity model, and other Random Utility Models.

The results also indicate that rural patients value obstetric beds and bassinets (beds for babies). The marginal utility for obstetric beds is 0.00387 and 0.00521 for bassinets. Considering the dis-utility of distance of 0.126, the willingness to travel (WTT) is 0.03 miles for obstetric beds and 0.0413 miles for bassinets, respectively. As such, rural mothers would be willing to travel an additional 0.03 miles for an increase of one obstetric bed and 0.0413 miles for a one unit increase in bassinets. Rural mothers value bassinets more than they value obstetrics beds. The estimates suggest that studies that do not consider bassinets when analyzing mother hospital decision are likely to be biased.

Additionally, the effects of Neonate Intensive Care Unit (NICU) on patients utility are given by the following linear relationship: $\frac{\partial U}{\partial NICU} = -0.38 + 0.769 * Risky$. For low-risk individuals, the marginal effect of NICU is -0.38 compared to 0.389 for high-risk individuals. High-risk patients are mothers over the age of 44 years or beyond 35 years and have had a previous c-section or had a c-section while having a plural birth (twin or triplets). The results suggest that those mothers value the characteristics of hospitals that have at least one NICU bed compared to facilities that do not have NICU beds. The WTT is 3.08 miles for high-risk mothers. As such, high-risk mothers are willing to travel an additional 3.08 miles for NICU hospitals. This willingness to travel is significant as it represents 9.5% of the average distance traveled by high-risk mothers. Therefore, NICU hospitals represent a contingency plan for high-risk mothers in case there is something wrong with the baby as those hospitals are often equipped with advanced technology and healthcare specialists to take care of the newborn. However, there is at least one reason why a low-risk rural mother may not be interested in a hospital that provides NICU services. Only 3.63% of hospitals located in rural areas offer NICU services [22]. NICU hospitals are generally located in large urban areas that are likely to be far from rural patients. Low-risk mothers are less likely to choose a NICU hospital far away considering the additional out-of-pocket transportation cost, the opportunity cost of time, the discomfort for the pregnant mother associated with driving additional miles, and the expectancy of a possible smooth pregnancy.

[22] When needed, the majority of the remaining hospitals transfer patients to NICU hospitals.

The results also show that rural mothers value hospitals accredited by the Joint Commission. Rural mothers are likely to go to these hospitals as they value their characteristics. As far as Academic Medical Centers, the estimated marginal utility is -0.738 for major teaching facilities and is -0.105 for minor teaching hospitals. Although teaching hospitals use cutting-edge technology to cure rare and complicated illness conditions, rural patients are less likely to deliver their babies in those facilities. Patients have greater dis-utility for major teaching hospitals relative to minor teaching facilities. There are at least two reasons for the negative marginal utility finding. First, University-affiliated hospitals are generally located in big cities that are likely to be far from rural patients. Second, less than 1% of maternity care providers in rural areas have privileges to admit patients in teaching hospitals, thereby reducing the likelihood that these facilities will be chosen even if they are in the mothers' choice set.

It is also worthwhile to note that some rural hospitals have affiliations with Academic Medical Centers. Although a patient chooses a rural community facility, depending on the complexity of the care needed, some patients may be overseen by specialists in academic medical centers through Telemedicine. Additionally, a significant fraction of teaching hospitals is considered Safety Net Hospitals (Sutton et al., 2016), which are providers of last resort who offer care to vulnerable populations such as Medicaid and uninsured individuals. But the fact that University-affiliated hospitals are primarily located in urban areas, vulnerable populations tend to go to Critical Access Hospitals or Sole Community Hospitals, which are likely to be nearer options, albeit with relatively lower quality care.

Furthermore, the results also show that rural mothers value the characteristics of public hospitals and non-profit hospitals relative to private for-profit hospitals. The estimated marginal utility is 0.0724 for public and 0.157 for non-profit hospital facilities. Considering the dis-utility of distance, the WTT is 0.57 miles for public and 1.25 miles for non-profit hospitals. As such, rural mothers value non-profit hospitals more than public and private hospitals as they are willing to travel an additional 1.25 miles for a unit increase in those institutions. 49% of hospitals in the country are non-profit institutions. As tax-exempted institutions, they are required to accept all patients irrespective of their financial situations or health insurance status. They are typically cheaper options for mothers than private for-profit institutions, while for-profit hospitals are generally better equipped with specialized materials. For-profit hospitals tend to provide more personalized care due to providers overseeing fewer patients per person.

Finally, the main results show that rural mothers do not value the characteristics of critical access hospital (CAH) as the marginal utility for CAH is -0.144. CAHs typically have no more than 25 beds and are located up to 35 miles away from another hospital. They also have an average length of stay of 96 hours and provide 24/7 emergency services. Although they are likely to be near rural patients relative to other health facilities, rural patients are less likely to go to those hospitals for delivery purposes. Among the possible reasons for this finding are the poor reputation and the low quality of care provided by those institutions (Taylor and Cosenza (1999); Liu et al. (2007)). Contrary to CAHs, the marginal utility is positive but statistically insignificant for Sole Community Hospitals (SCH). Given that those facilities were designed to provide care to very remote areas, it may be that they represent the unique source of care for some individuals.

7 Robustness Checks

7.1 Mother Heterogeneity Analysis

Location and quality may mean something entirely different for several distinct sub-population groups. As such, in Table 3, we present a mother observable heterogeneity analysis by estimating the model for the following sub-categories: black, white, Hispanic, other-race (e.g., Asian), high education (some college or more), low education (high school and below), married, and non-married. In Table 4, we analyze the following sub-categories: teenage mothers (21 years or less), young (between 21 and 34 years, relatively lower birth complications), old (35 years and above, relatively higher birth complications), Medicaid, private insurance, uninsured individuals, elective C-section, and induction of labor.

The first rows of Table 3 and Table 4 show that all the sub-groups have negative marginal utilities for distance. So, it doesn't matter the race, education, marital status, age (teen or young), public insurance status, or private; all these types of rural mothers dislike distance. Also, all the race groups have positive valuations for obstetric beds and bassinets, with the other-race group (e.g., Asian) having relatively higher WTT for obstetric beds and Hispanics for bassinets. While mothers with higher education value obstetric beds relatively more than lower education level mothers, this is the opposite for bassinets. Overall, for all the different sub-groups considered, obstetric beds are statistically significant to explain a mother's hospital choice, except for insurance status. Medicaid patients for whom delivery cost is irrelevant and private insurance holders for whom price may also be somewhat irrelevant have statistically insignificant effects for obstetric beds. In contrast, the sub-analysis by insurance status reveals that all the sub-categories value bassinets, with Medicaid patients having relatively greater WTT.

The mother heterogeneity analysis shows that all low-risk mothers, including education levels, marital status, age (teen or young), insurance levels such as Medicaid or private, have negative marginal utilities for hospitals with Neonate Intensive Care Units beds. These low-risk groups probably dislike the fact that they would have to drive significantly more miles to reach a NICU hospital, given that only 3.63% of hospitals located in rural areas offer NICU services. Besides the higher out-of-pocket transportation cost, the more significant discomfort related to several prenatal visits in a possibly far away NICU hospital, low-risk rural mothers probably expect a smooth delivery, which may not necessitate a contingency plan in their views.

The heterogeneity analysis shows that high-risk mothers have strong valuations for NICU hospitals. High-risk black mothers are willing to travel 3.66 additional miles to a hospital with at least one NICU bed. This willingness to travel represents 11% of the distance traveled by the average high-risk black mother. The WTT is 3.09 miles for high-risk white mothers, 1.24 miles for high-risk Hispanic mothers, and 3.93 miles for high-risk other-race (e.g., Asian) mothers. As far as education level, lower education low-risk mothers have one more mile in terms of willingness to travel to NICU hospitals than higher education high-risk mothers, with the average distance being almost the same for these two groups. Besides, high-risk teenage mothers have a 10.4 miles willingness to travel to a NICU hospital, representing 32% of the average distance traveled by those mothers. Given that high-risk teenage mothers may not even have a fully developed body themselves, they are likely to give birth to a baby that necessitates the care of trained neonatologists and be in a facility with very advanced equipments. As such, choosing a NICU hospital to give birth may represent an emergency exit plan for high-risk teenage mothers.

Overall, the heterogeneity analysis shows that high-risk mothers value the characteristics of NICU hospitals and are likely to go to those institutions to deliver their babies if they have them in their choice set. However, the analysis also shows that high-risk old patients and high-risk elective c-section patients have negative marginal utilities for hospitals with NICU beds. There are several reasons why those patients may have negative marginal utilities for NICU hospitals. Based on our definition of riskiness, a patient is high-risk when she is approaching the end of the reproductive spectrum (49 years) or being somewhat old (35 years) and had a previous c-section or a plural birth. Some of the old patients that fit our riskiness criterion may well be old and had a previous c-section, but also had one or several vaginal births after the c-section. About 13% of mothers that had a previous c-section have a vaginal birth with no meaningful complications later. Considering the spatial constraint associated with going to a NICU, old rural mothers who expect a smooth birth process may be less likely to choose a NICU hospital.

Regarding elective c-section patients, they are mothers who scheduled a c-section for non-medical reasons. Elective c-section patients who fit our riskiness description are likely to be old mothers who did not present a significant risk because physicians would not have authorized the elective c-section if the patients were relatively risky. As such, these patients may not be interested in a NICU hospital if they expect a smooth birth process and/or have a major spatial constraint.

Additionally, the heterogeneity analysis shows that all race groups, except blacks, have positive and statistically significant marginal utilities for hospitals accredited by the Joint Commission, which is the reference in terms of hospital quality and safety standards. The other race categories have the following WTT for accredited hospitals: 0.42 miles for whites, 0.85 for other-race (e.g., Asian), and 1.12 miles for Hispanics. The results also indicate that low education mothers have slightly more willingness to travel to accredited hospitals than high education mothers, and non-married also have a somewhat higher WTT than married individuals. However, privately insured mothers have a relatively greater desire to travel additional miles for accredited hospitals than Medicaid mothers. Uninsured mothers who have no insurance networking constraint show a greater willingness to travel for accredited hospitals than Medicaid and private insurance mothers.

All the sub-groups (16 in total, considering Table 3 and Table 4) have negative marginal utilities for Academic Medical Centers. University-affiliated hospitals such as Major and Minor teaching hospitals use cutting-edge technological equipment to treat rare and complicated diseases. However, several factors may explain why rural mothers do not choose teaching hospitals to give birth. The location of those University-affiliated institutions typically imposes a spatial constraint on rural mothers. As such, they are likely to select and value closer alternatives relatively more, although sometimes of less quality. In settings where the physician chooses the childbirth location, it is also the case that teaching hospital facilities are less likely to be selected even if they are in patients' choice set. Less than 1% of maternity care providers in rural communities have the right to admit patients to teaching hospitals, which reduces the likelihood a provider will refer a patient to an Academic Medical Center.

Additionally, the sub-category analysis indicates that among the different race groups, only Hispanics and white have positive and statistically significant marginal satisfaction for public hospitals compared to private for-profit institutions. The effects are positive for blacks and other-race (e.g., Asian), but they are statistically insignificant. The willingness to travel for public hospitals is the greatest for Hispanics, 1.33 miles. Both high and low education groups value the characteristics of public hospitals more than private for-profit hospitals, with higher education groups having a somewhat higher WTT. Both married and non-married groups are more satisfied with the characteristics of public hospitals than private for-profit institutions, with married mothers having a greater WTT. As far as insurance coverage, Medicaid mothers have the lowest willingness to travel for public hospitals (0.60 miles) while uninsured individuals have the highest (2.06 miles). This makes sense because uninsured individuals are more sensitive to delivery costs than insurance holders, and public hospitals are generally cheaper than private for-profit institutions.

Black is the only race group that values private for-profit hospitals' characteristics more than non-profit hospitals. Although private for-profit hospitals are generally more expensive, they have relatively shorter waiting periods, more personalized care, and better technological equipment than non-profit hospitals. All the other sub-populations categories value the characteristics of non-profit hospitals more than public and private for-profit institutions. Additionally, the different groups have negative marginal satisfaction for critical access hospitals while Hispanics and the other-race (e.g., Asian) are likely to choose Sole Community Hospitals as they provide them positive marginal utilities.

In general, mothers may be exposed to very different societal factors, and the underlying health and social inequities across groups may differ. However, the fact that heterogeneity analysis across the 16 groups is robust and consistent provides some faith in the estimation design and that the results are not likely to be driven by unobserved confounders.

7.2 Control Group

To further check our results' sensitivity to potential unobserved hospital heterogeneity, we present a table showing the differences by education and health insurance status where we aim to demonstrate that the effect of quality is lower when it should be lower. Hence, we use a control group of mothers whose choice of hospital is likely to be less subject to quality. We hypothesize that poor mothers of low education are less likely to respond to hospital quality than non-poor-college-educated mothers. Given that we don't observe income measures in the data, we use Medicaid status as a proxy for mother's poverty. Medicaid pays for the delivery of low-income patients up to 60 days postpartum. As low education criterion, we use high school level and below. As such, for the control group, we consider mothers whose delivery was paid by Medicaid and whose highest level of education accomplished was a high school degree or less. We argue that these low-income-low-education rural mothers are less likely to respond to quality. Their hospital choices are likely to be mainly driven by distance. On the other hand, highly educated private insurance holders are more likely to have relatively lower dis-utility for distance.

Table 6 below presents the results of the control group analysis. The results show that poor low-education mothers and non-poor-college-educated mothers behave the way we expect for all the quality metrics, except for NICU beds. Although the willingness to travel for a quality hospital is almost always higher for college-educated who hold private insurance, the difference in terms of WTT is not meaningful. However, college-educated private insurance holders have lower dis-utility for additional distance traveled than the control group. Overall, the result suggests that mothers in the control group are somewhat less subject to quality care and are mainly driven by distance, while college-educated and privately insured mothers expressed relatively lower dis-utility for longer distances.

7.3 Choice Set Expansion and Contraction

Thus far, we use a market area of 50 miles to evaluate the tradeoff of interest. To further check the robustness of the results to potential unobserved confounders, we use two different specifications: 1) expand the choice set up to 60 miles beyond the county of residence, and 2) shrink the option set to 40 miles. These specifications are equivalent to adding 10 miles (or alternative hospital choices to each individual) and removing 10 miles (or removing alternative hospital choices). Table 7 below presents the choice set expansion and contraction models' results. For the 40-miles radius, on average, mothers have 12 hospitals in their choice sets compared to 18 and 27 for the 50-miles radius (main specification) and 60-miles radius, respectively. Only 6.7% of individuals go outside the 50-miles radius for the main specification, and only 3.5% go beyond the 60-miles. The market area population coverage is very high, and the ghost county is not a suitable option for most people.

Overall, for all the quality metrics, the tradeoff decreases with respect to the radius of the choice set. The larger the choice set, the lower the willingness to travel for more quality, which makes sense because rural have strong dis-utility for driving further distances. This negative relationship can be witnessed in the estimated marginal utilities for distance and ghost county. The dis-utility to go outside the defined market area is -0.57 for the 40-miles radius, -1.437 for the 50-miles radius, and -1.988 for the 60-miles radius. But, the choice set expansion and contraction analysis shows that the three models reach the same qualitative conclusion in terms of which types of hospitals rural mothers value. Rural mothers value obstetric beds, bassinets (beds for babies), accredited hospitals, public hospital facilities, and non-profit institutions. High-risk rural mothers value NICU hospitals, while low-risk individuals do not value the characteristics of NICU hospitals. The three models also conclude that patients expressed dis-utility for distance, University-affiliated institutions, and Critical Access Hospitals to deliver their babies. As such, mothers are likely to choose the hospitals for whom they express strong valuations and not likely to go to hospitals that they do not value much.

Adding or removing 10 miles to the main specification doesn't change the main specification's conclusion. Also, considering the Independent and Irrelevant Alternatives (IIA) [23] hypothesis, if the model is well specified, one shouldn't expect a different conclusion when adding or removing hospitals from the mothers' choice sets. As such, the fact that the baseline estimates are robust to the various choice set definitions shows that the model is well specified, and the results are unlikely to be driven by unobserved confounders.

8 Conclusion

For this analysis, we consider a choice set of 50 miles between the centroid of the county of residence and birth occurrence for rural mothers who gave birth between 2007 and 2017. This yields 113,488,826 individual-hospital matched observations for a total of 6,039,936 rural mothers and an average of 18 hospitals in the mothers' choice set. The average distance traveled by the rural mothers in the sample period is 32.24 miles. Overall, 6.7% of the rural

[23] McFadden (1986) argues that it is possible to steer clear of the IIA limitation but stay within the confines of the MNL family by allowing the strict utilities for an alternative to be a function of features of the choice set. In this way, the model avoids IIA restrictions but maintains some of the computational advantages of the MNL framework.

mothers bypass the 50 miles to deliver their babies, with the majority being white. The estimates show that rural mothers have strong disutility for further distances. Mothers also expressed strong negative valuations for counties outside of the 50-miles radius from their county of residence.

Blacks have a higher dis-utility to go beyond 50 miles for childbirth, while college-educated and privately insured mothers expressed relatively lower dis-utility for longer distances. The latter groups are likely to have extensive insurance coverage, and high purchasing power insofar as traveling further miles may cost them less than the average rural mother. The fact that patients express disutility for additional distances makes sense because further distance means higher direct out-of-pocket transportation costs, opportunity costs of time, and more significant discomfort for a pregnant mother. Our findings are consistent with the distance decay hypothesis, the gravity model, and several other random utility models utilized in the literature.

The results find that rural mothers value obstetrics beds and bassinets (beds for babies). Rural mothers would be willing to travel an additional 0.03 miles for an extra obstetric bed and 0.0413 miles for an additional bed for babies. Hence, the mothers value bassinets more than they value obstetrics beds. The other-race group (e.g., Asian) has a relatively higher willingness to travel for obstetric beds, and Hispanics show a greater desire to travel for bassinets. While mothers with higher education value obstetric beds relatively more than lower education level mothers, this is the opposite for bassinets.

We also analyze the tradeoff between distance traveled and hospital quality for high-risk and low-risk patients. High-risk patients are mothers over the age of 44 years or beyond 35 years and have had a previous c-section or had a c-section while having a plural birth (twin or triplets). On the one hand, the results show that all types of low-risk patients, such as education levels, marital status, age, and insurance levels, express strong negative marginal utilities for Neonate Intensive Care Unit hospitals. Those hospitals are often equipped with advanced technology and healthcare specialists to take care of the newborn. They are generally located in large urban areas that are likely to be far from rural patients. Low-risk mothers are less likely to choose a NICU hospital far away, considering the additional out-of-pocket transportation cost, the opportunity cost of time, the discomfort for the pregnant mother associated with driving extra miles, and the expectancy of a possibly smooth delivery.

On the other hand, high-risk patients strongly value the characteristics of Neonate Intensive Care Unit hospitals relative to non-NICU institutions. High-risk mothers are willing to travel an additional 3.08 miles to go to a NICU hospital, which represents 9.5% of the average distance traveled by those mothers. High-risk black mothers are willing to travel 3.66 (or 11%) additional miles to a hospital with at least one NICU bed. The desire to travel extra miles is 3.93 miles for high-risk other-race (e.g., Asian), 3.09 miles for high-risk white mothers, and 1.24 miles for high-risk Hispanic mothers. High-risk mothers below the age of 21 are willing to travel 10.4 or 32% more miles to go to a NICU hospital. Considering that high-risk teenage mothers may not even have a fully mature body themselves, they are likely to give birth to a baby that necessitates the care of trained neonatologists and be in a facility with very advanced equipment. Thereby, choosing a NICU hospital to give birth may represent an emergency exit plan for high-risk mothers if there is something wrong with the baby, as those hospitals are often equipped with advanced technology and healthcare specialists to take care of the newborn.

Although Academic Medical Centers use cutting-edge technological equipment to cure rare and complicated diseases, rural mothers are less likely to select those institutions for delivery purposes. Rural patients show strong negative valuations for the characteristics of University-affiliated hospitals for several reasons. Teaching hospitals are generally located in urban areas that may be far away from rural patients. As such, low-risk patients that expect a smooth delivery are less likely to choose those hospitals as they are associated with money costs and discomfort for a pregnant mother. Also, very few rural providers have admitting privileges in University-affiliated hospitals, which reduces the likelihood that a rural provider will refer a patient to an Academic Medical Center for delivery. While rural patients have negative marginal utility for major and minor teaching hospitals, they express strong valuations for hospitals accredited by the Joint Commission. Privately insured mothers have a relatively greater desire to travel additional miles for accredited hospitals than Medicaid mothers. On the other hand, uninsured mothers who have no insurance networking constraint show a greater willingness to travel for accredited hospitals than Medicaid and private insurance mothers.

As far as hospital ownership, rural mothers value the characteristics of non-private for-profit institutions more than they value private for-profit hospitals, with relatively stronger valuations for non-public than public hospitals. The willingness to travel for public hospitals is the greatest among Hispanics, 1.33 miles. Both married and non-married groups are more satisfied with the characteristics of public hospitals than private for-profit institutions. Regarding insurance coverage, uninsured individuals have the highest willingness to travel, 2.06 miles. This makes sense because uninsured individuals are more sensitive to delivery costs than insurance holders, and public hospitals are generally cheaper than private for-profit institutions. Private for-profit hospitals are usually more expensive, have relatively shorter waiting periods, more personalized care, and better technological equipment than non-profit hospitals.

This paper raises several issues and makes important policy considerations. The results show that rural mothers express strong disutility for additional distance traveled and have strong valuations for better quality hospitals. Our findings make sense because low accessibility, low availability, and low quality of maternity care have serious negative consequences on mothers' and infants' outcomes. Distance traveled is associated with reductions in health care utilization, higher rates of c-section and neonatal hypoglycemia (Robbins et al., 2019), and higher rates of adverse perinatal outcomes (Grzybowski et al. (2011), Ravelli et al. (2011)). Women living in communities with obstetric care shortages have a relatively higher proportion of delivery complications, higher prematurity rates, and greater neonatal care costs (Nesbitt et al., 1990).

The study's findings have substantial policy implications. First, the results suggest that investing in the expansion of health care facilities will improve patient satisfaction by reducing travel time. Second, our results also suggest that investing in public transportation or, at least, reducing transportation costs for low-income populations is likely to improve patient satisfaction. Medicaid patients are more sensitive to distance than privately insured patients (Phibbs et al., 1993), and public transportation is critical for health care delivery (Evans and Lien, 2005). Third, investment in quality care is also instrumental for patient satisfaction.

The policy recommendations matter because nearly 35% of US counties have no obstetrician-gynecologists (March of Dimes, 2018), and 56% have no nurse-midwives (ACNM, 2018). The American Congress of Obstetrician-Gynecologists (ACOG) estimated a shortage of up to 8,800 Ob-gyn by 2020. This workforce shortage and the closures of several rural hospitals are likely to dampen the already low-accessibility and low-quality care in rural areas. Consequently, the key stakeholders need to expand and provide seamless maternity care of good quality in rural areas.

References

Adams, E. K., Houchens, R., Wright, G. E., and Robbins, J. (1991). Predicting hospital choice for rural medicare beneficiaries: the role of severity of illness. *Health Services Research*, 26(5):583.

Andersen, R. et al. (1968). A behavioral model of families' use of health services. *A behavioral model of families' use of health services.*, (25).

Anhang Price, R., Elliott, M. N., Zaslavsky, A. M., Hays, R. D., Lehrman, W. G., Rybowski, L., Edgman-Levitan, S., and Cleary, P. D. (2014). Examining the role of patient experience surveys in measuring health care quality. *Medical Care Research and Review*, 71(5):522–554.

Axon, R. N. and Williams, M. V. (2011). Hospital readmission as an accountability measure. *Jama*, 305(5):504–505.

Boscarino, J. A. (1988). The public's rating of hospitals. *Journal of Healthcare Management*, 33(2):189.

Boscarino, J. A. (1992). The public's perception of quality hospitals: implications for patient surveys. *Hospital & health services administration*, 37(1):13–36.

Bronstein, J. M. and Morrisey, M. A. (1991). Bypassing rural hospitals for obstetrics care. *Journal of Health Politics, Policy and Law*, 16(1):87–118.

Buchmueller, T. C., Jacobson, M., and Wold, C. (2006). How far to the hospital?: The effect of hospital closures on access to care. *Journal of health economics*, 25(4):740–761.

Cecil (2020). Cecil g. sheps center for health services research.

Chandra, A., Finkelstein, A., Sacarny, A., and Syverson, C. (2016). Health care exceptionalism? performance and allocation in the us health care sector. *American Economic Review*, 106(8):2110–44.

Cleveland, L. M. (2008). Parenting in the neonatal intensive care unit. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, 37(6):666–691.

CMS (2018). Improving access to maternal health care in rural communities.

Conner, J. M. and Nelson, E. C. (1999). Neonatal intensive care: satisfaction measured from a parent's perspective. *Pediatrics*, 103(Supplement E1):336–349.

Currie, J. and Reagan, P. B. (2003). Distance to hospital and children's use of preventive care: is being closer better, and for whom? *Economic Inquiry*, 41(3):378–391.

Dimes, M. O. (2018). Nowhere to go maternity care deserts across the u.s.

Donabedian, A. (1966). Evaluating the quality of medical care. *The Milbank memorial fund quarterly*, 44(3):166–206.

Douthit, N., Kiv, S., Dwolatzky, T., and Biswas, S. (2015). Exposing some important barriers to health care access in the rural usa. *Public health*, 129(6):611–620.

Evans, W. N. and Lien, D. S. (2005). The benefits of prenatal care: evidence from the pat bus strike. *Journal of Econometrics*, 125(1-2):207–239.

Freedman, S., Lin, H., and Simon, K. (2015). Public health insurance expansions and hospital technology adoption. *Journal of Public Economics*, 121:117–131.

Garnick, D. W., Luft, H. S., Robinson, J. C., and Tetreault, J. (1987). Appropriate measures of hospital market areas. *Health services research*, 22(1):69.

Grzybowski, S., Stoll, K., and Kornelsen, J. (2011). Distance matters: a population based study examining access to maternity services for rural women. *BMC health services research*, 11(1):1–8.

Gutacker, N., Siciliani, L., Moscelli, G., and Gravelle, H. (2016). Choice of hospital: Which type of quality matters? *Journal of health economics*, 50:230–246.

Hausknecht, J. P., Hiller, N. J., and Vance, R. J. (2008). Work-unit absenteeism: Effects of satisfaction, commitment, labor market conditions, and time. *Academy of management journal*, 51(6):1223–1245.

Jencks, S. F., Williams, M. V., and Coleman, E. A. (2009). Rehospitalizations among patients in the medicare fee-for-service program. *New England Journal of Medicine*, 360(14):1418–1428.

Jha, A. K., Li, Z., Orav, E. J., and Epstein, A. M. (2005). Care in us hospitals—the hospital quality alliance program. *New England Journal of Medicine*, 353(3):265–274.

Jha, A. K., Orav, E. J., Li, Z., and Epstein, A. M. (2007). The inverse relationship between mortality rates and performance in the hospital quality alliance measures. *Health affairs*, 26(4):1104–1110.

Klein, M. W., Malone, M. F., Bennis, W. G., and Berkowitz, N. H. (1961). Problems of measuring patient care in the out-patient department. *Journal of Health and Human Behavior*, 2(2):138–144.

Kozhimannil, K. B., Hung, P., Henning-Smith, C., Casey, M. M., and Prasad, S. (2019). Association between loss of hospital-based obstetric services and birth outcomes in rural counties in the united states. *Jama*, 319(12):1239–1247.

Lam, M. B., Figueroa, J. F., Feyman, Y., Reimold, K. E., Orav, E. J., and Jha, A. K. (2018). Association between patient outcomes and accreditation in us hospitals: observational study. *bmj*, 363.

Lee, R. I. (1933). *The fundamentals of good medical care: an outline of the fundamentals of good medical care and an estimate of the service required to supply the medical needs of the United States*. University of Chicago Press.

Levin, R., Moy, E., and Griner, P. F. (2000). Trends in specialized surgical procedures at teaching and nonteaching hospitals: The concentration of specialized surgery in major teaching hospitals may help to explain some perplexing quality and outcomes results. *Health Affairs*, 19(1):230–238.

Lipworth, L., Lee, J., and Morris, J. (1963). Case-fatality in teaching and non-teaching hospitals 1956-59. *Medical Care*, pages 71–76.

Liu, H., Mroz, T. A., and Van der Klaauw, W. (2010). Maternal employment, migration, and child development. *Journal of Econometrics*, 156(1):212–228.

Liu, J., Bellamy, G. R., and McCormick, M. (2007). Patient bypass behavior and critical access hospitals: implications for patient retention. *The Journal of Rural Health*, 23(1):17–24.

Luft, H. S., Garnick, D. W., Mark, D. H., Peltzman, D. J., Phibbs, C. S., Lichtenberg, E., and McPhee, S. J. (1990). Does quality influence choice of hospital? *Jama*, 263(21):2899–2906.

Mayo-Clinic (2020). Healthy lifestyle, high-risk pregnancy: Know what to expect. https://www.mayoclinic.org/healthy-lifestyle/pregnancy-week-by-week/in-depth/high-risk-pregnancy/art-20047012.

McFadden, D. (1986). The choice theory approach to market research. *Marketing science*, 5(4):275–297.

McGuirk, M. A. and Porell, F. W. (1984). Spatial patterns of hospital utilization: the impact of distance and time. *Inquiry*, pages 84–95.

Mishori, R. (2003). Scare season.

Moffett, M. L., Morgan, R. O., and Ashton, C. M. (2005). Strategic opportunities in the oversight of the us hospital accreditation system. *Health policy*, 75(1):109–115.

Morrill, R. L. and Earickson, R. (1968). Hospital variation and patient travel distances. *Inquiry*, pages 26–34.

Morrill, R. L., Earickson, R. J., and Rees, P. (1970). Factors influencing distances traveled to hospitals. *Economic geography*, 46(2):161–171.

Morrisey, M. A., Sloan, F. A., and Valvona, J. (1988). Defining geographic markets for hospital care. *Law & Contemp. Probs.*, 51:165.

Moscelli, G., Siciliani, L., Gutacker, N., and Gravelle, H. (2016). Location, quality and choice of hospital: Evidence from england 2002–2013. *Regional Science and Urban Economics*, 60:112–124.

NAVY (1987). Admiralty manual of navigation, volume 1, revised 1987.

Nesbitt, T. S., Connell, F. A., Hart, L. G., and Rosenblatt, R. A. (1990). Access to obstetric care in rural areas: effect on birth outcomes. *American Journal of Public Health*, 80(7):814–818.

NYAM (1955). *Perinatal Mortality in New York City: Responsible Factors; a Study of 955 Deaths by the Subcommittee on Neonatal Mortality, Committee on Public Health Relations, the New York Academy of Medicine (NYAM).* Harvard UP; Oxford UP.

Phibbs, C. S., Mark, D. H., Luft, H. S., Peltzman-Rennie, D. J., Garnick, D. W., Lichtenberg, E., and McPhee, S. J. (1993). Choice of hospital for delivery: a comparison of high-risk and low-risk women. *Health Services Research*, 28(2):201.

Porell, F. W. and Adams, E. K. (1995). Hospital choice models: a review and assessment of their utility for policy impact analysis. *Medical Care Research and Review*, 52(2):158–195.

Premkumar, D., Jones, D., and Orazem, P. (2016). Hospital closure and hospital choice: How hospital quality and availability will affect rural residents.

Ravelli, A., Jager, K., De Groot, M., Erwich, J., Rijninks-van Driel, G., Tromp, M., Eskes, M., Abu-Hanna, A., and Mol, B. (2011). Travel time from home to hospital and adverse perinatal outcomes in women at term in the netherlands. *BJOG: An International Journal of Obstetrics & Gynaecology*, 118(4):457–465.

Robbins, L. S., Champion, M. L., Wetta, L. A., Casey, B. M., and Harper, L. M. (2019). 749: Impact of distance traveled to prenatal care on outcomes of pregnancies complicated by pregestational diabetes. *American Journal of Obstetrics & Gynecology*, 220(1):S491–S492.

Roghmann, K. J. and Zastowny, T. R. (1979). Proximity as a factor in the selection of health care providers: emergency room visits compared to obstetric admissions and abortions. *Social Science & Medicine. Part D: Medical Geography*, 13(1):61–69.

Roh, C.-Y., Lee, K.-H., and Fottler, M. D. (2008). Determinants of hospital choice of rural hospital patients: the impact of networks, service scopes, and market competition. *Journal of Medical Systems*, 32(4):343–353.

Shapiro, S., Jacobziner, H., Densen, P. M., and Weiner, L. (1960). Further observations on prematurity and perinatal mortality in a general population and in the population of a prepaid group practice medical care plan. *American Journal of Public Health and the Nations Health*, 50(9):1304–1317.

Sixma, H. J., Kerssens, J. J., Campen, C. v., and Peters, L. (1998). Quality of care from the patients' perspective: from theoretical concept to a new measuring instrument. *Health expectations*, 1(2):82–95.

Sutton, J. P., Washington, R. E., Fingar, K. R., and Elixhauser, A. (2016). Characteristics of safety-net hospitals, 2014: statistical brief# 213.

Tay, A. (2002). What can patient outcomes tell us about hospital quality. Technical report, Citeseer.

Tay, A. (2003). Assessing competition in hospital care markets: the importance of accounting for quality differentiation. *RAND Journal of Economics*, pages 786–814.

Taylor, S. L. and Cosenza, R. M. (1999). A conceptual choice model for hospital services. *Journal of Marketing theory and Practice*, 7(4):20–32.

White, W. D. and Morrisey, M. A. (1998). Are patients traveling further? *International Journal of the Economics of Business*, 5(2):203–221.

Figure 1

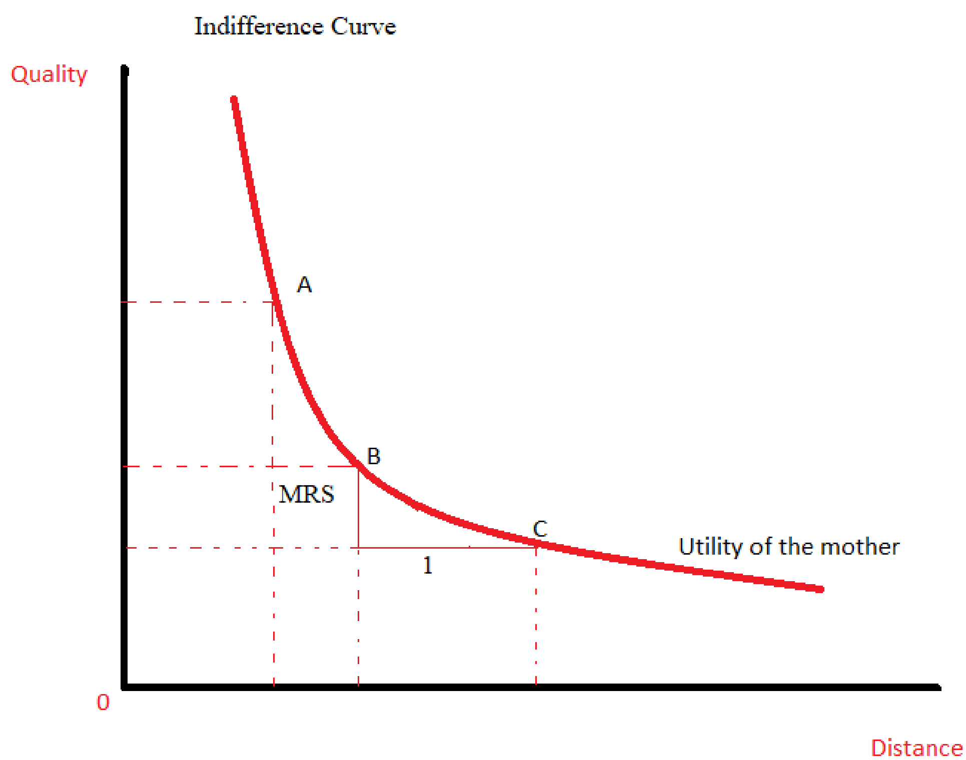
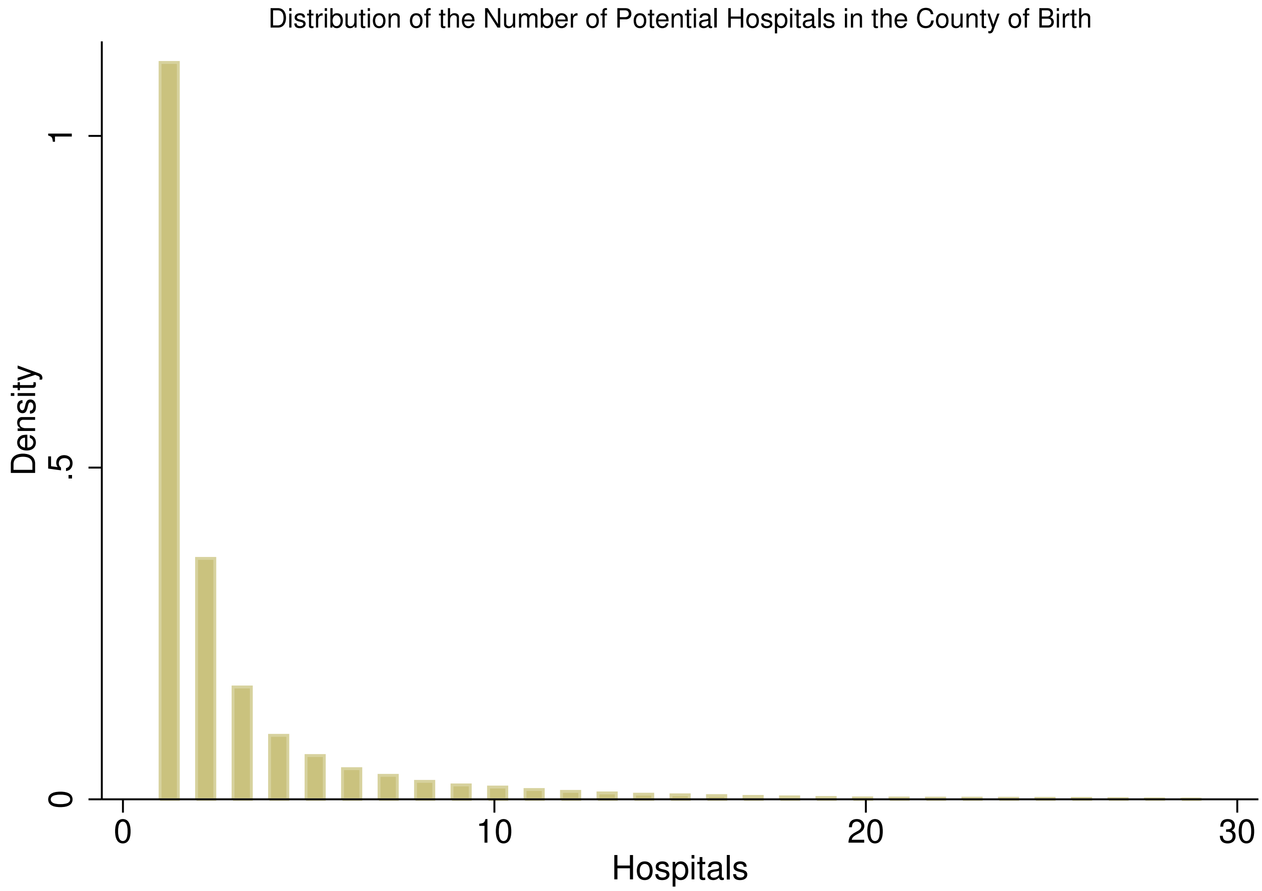

Indifference Curve
Quality
A
B
MRS
C
1
Utility of the mother
0
Distance

Figure 2



Distribution of the Number of Potential Hospitals in the County of Birth
Density
0
.5
1
0
10
20
30
Hospitals

Table 1: Descriptive Statistics

	Mean	Standard Deviation
Distance and Quality Metrics		
Distance (in Miles)	32.24	14.75
Obstetric beds	7.88	13.26
Neonate Intensive Care Unit	0.12	0.32
Bassinets (beds for babies)	8.21	12.3
Accredited Hospitals	0.66	0.46
Major Teaching Hospital	0.024	0.15
Minor Teaching Hospital	0.18	0.38
Public Hospital	0.23	0.42
Non-Profit Hospital	0.49	0.50
Critical Access Hospital	0.24	0.41
Sole Community Hospital	0.048	0.21
Hospital Characteristics		
Maternity Providers With Admitting Privileges	40.3	74.9
Registered Nurses	194	326
Individual Characteristics		
High-risk	0.06	0.23
20-24 years	0.30	0.46
25-34 years	0.50	0.50
35-44 years	0.09	0.29
White	0.70	0.46
Black	0.09	0.29
Hispanic	0.08	0.27
Married	0.57	0.50
Several Children	0.62	0.48
More than High School	0.49	0.47
Bypasser	0.067	0.25
Black Bypasser	0.006	0.08
Hispanic Bypasser	0.006	0.08
White Bypasser	0.05	0.21
Community Characteristics		
Unemployment rate	6.98	2.69
Medicaid reimbursement rates for Obstetrics Care ($)	1333	266
ACA	0.18	0.38
Certificate of Need Law	0.73	0.43
Any Child-related Immigrant Friendly Policy	0.59	0.47
Individual-Hospital Observations	113,488,826	
Rural Mothers Over the Period	6,039,936	
Average Number of Hospital Per Individual	18	

Notes: Authors' analysis using Vital Statistics & American Hospital Annual Survey Data. The maternity care providers with admitting privileges are obstetrician and gynecologists, geriatrics, family practice doctors, general internal doctors, and general practitioners who can admit patients to specific hospitals. In rural communities, those doctors are generally the ones who provide obstetric care (Dimes, 2018).

Table 2: Estimates of Marginal Utility

	Coefficient	Standard Errors
Distance Metrics		
Distance	-0.126***	(0.000183)
Ghost County	-1.437***	(0.0195)
Hospital Quality Metrics		
Obstetric beds	0.00387***	(0.00061)
Bassinets (beds for babies)	0.00521***	(0.00063)
Neonate Intensive Care Unit (NICU)	-0.38***	(0.0134)
High-risk*NICU	0.769***	(0.0211)
Accredited Hospitals	0.0573***	(0.00065)
Major Teaching Hospitals	-0.738***	(0.0529)
Minor Teaching Hospitals	-0.105***	(0.0098)
Public Hospitals	0.0724***	(0.0089)
Non-Profit Hospitals	0.157***	(0.0084)
Hospital Low Quality Metrics		
Critical Access Hospitals	-0.144***	(0.009)
Sole Community Hospitals	0.009	(0.0106)
Individual-Hospitals	113,488,826	
Individual	6,039,936	

Notes: Authors' analysis using Vital Statistics & American Hospital Annual Survey Data for the years 2007-2017. The model controls for distance and different hospital quality metrics. A high-risk individual is a mother over the age of 44 years or that is beyond 35 years and have had a previous c-section, or a mother that had a c-section and a plural birth. The model also controls for hospital size variables (different indicators for total hospital beds, outpatient visits, registered nurses and other personnels, number of registered nurses adjusted by the state scope of practice laws, number of maternity care providers with admitting privileges, and hospital total expenses), community characteristics (unemployment rate, Medicaid expansion, obstetric reimbursement rates, certificate of needs law, poverty rates, household income, and county population). The standard errors are clustered at the individual level.

Table 3: Estimates of Marginal Utilities for Different Sub-Categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All	Black	White	Hispanic	Other-race	High Education	Low Education	Married	Non-Married
Distance Metrics									
Distance	-0.126***	-0.145***	-0.131***	-0.108***	-0.110***	-0.119***	-0.133***	-0.122***	-0.133***
	(0.000183)	(0.000701)	(0.000229)	(0.000515)	(0.000453)	(0.000257)	(0.000291)	(0.000236)	(0.000292)
Ghost County	-1.437***	-1.899***	-1.404***	-1.313***	-1.208***	-1.257***	-1.569***	-1.238***	-1.679***
	(0.0195)	(0.0721)	(0.0248)	(0.0587)	(0.0493)	(0.0280)	(0.0307)	(0.0258)	(0.0304)
Hospital Quality									
Obstetric Beds	0.00387***	0.00567***	0.00371***	0.00258	0.00820***	0.00292***	0.00167*	0.00495***	0.00273***
	(0.00061)	(0.00192)	(0.000784)	(0.00186)	(0.00158)	(0.000905)	(0.000975)	(0.000808)	(0.000948)
Bassinets	0.00521***	0.0102***	0.00421***	0.0110***	0.00206	0.00504***	0.00610***	0.00430***	0.00641***
	(0.00063)	(0.00199)	(0.000796)	(0.00196)	(0.00160)	(0.000914)	(0.000991)	(0.000831)	(0.000961)
NICU	-0.38***	-0.252***	-0.422***	-0.400***	-0.282***	-0.379***	-0.388***	-0.400***	-0.350***
	(0.0134)	(0.0477)	(0.0173)	(0.0401)	(0.0308)	(0.0191)	(0.0212)	(0.0178)	(0.0206)
High-risk*NICU	0.769***	0.783***	0.827***	0.534***	0.715***	0.661***	0.836***	0.685***	0.860***
	(0.0211)	(0.0780)	(0.0260)	(0.0651)	(0.0542)	(0.0278)	(0.0370)	(0.0253)	(0.0389)
Accredited Hospitals	0.0573***	0.0258	0.0549***	0.121***	0.0932***	0.0566***	0.0700***	0.0609***	0.0541***
	(0.00065)	(0.0250)	(0.00808)	(0.0207)	(0.0162)	(0.00945)	(0.0102)	(0.00864)	(0.0101)
Major Teaching Hospital	-0.738***	-0.821***	-0.681***	-0.987***	-0.783***	-0.665***	-0.807***	-0.677***	-0.820***
	(0.0529)	(0.233)	(0.0633)	(0.217)	(0.124)	(0.0685)	(0.0897)	(0.0676)	(0.0854)
Minor Teaching Hospitals	-0.105***	-0.0923**	-0.119***	-0.0260	-0.127***	-0.118***	-0.0970***	-0.113***	-0.0932***
	(0.0098)	(0.0465)	(0.0123)	(0.0306)	(0.0216)	(0.0134)	(0.0154)	(0.0128)	(0.0153)
Public Hospitals	0.0724***	0.0225	0.0917***	0.144***	0.0319	0.0706***	0.0659***	0.0916***	0.0562***
	(0.0089)	(0.0282)	(0.0116)	(0.0257)	(0.0231)	(0.0134)	(0.0138)	(0.0119)	(0.0137)
Non-Profit Hospitals	0.157***	-0.0666**	0.208***	0.132***	0.0931***	0.191***	0.147***	0.180***	0.131***
	(0.0.0084)	(0.0279)	(0.0106)	(0.0244)	(0.0220)	(0.0124)	(0.0129)	(0.0111)	(0.0129)
Low Quality									
Critical Access Hospitals	-0.144***	-0.249***	-0.134***	-0.167***	-0.176***	-0.138***	-0.145***	-0.136***	-0.153***
	(0.009)	(0.0360)	(0.0116)	(0.0284)	(0.0244)	(0.0136)	(0.0147)	(0.0123)	(0.0146)
Sole Community Hospitals	0.009	-0.00984	0.000234	0.0961***	0.0433*	-0.000185	-0.00376	0.0117	0.00766
	(0.0106)	(0.0425)	(0.0137)	(0.0290)	(0.0244)	(0.0153)	(0.0168)	(0.0140)	(0.0164)
Individual-Hospitals	113,488,826	10,369,975	79,653,506	9,508,859	13,956,486	50,144,748	63,344,078	63,946,744	49,542,282
Individual (births)	6,039,936	552,181	4,241,400	506,329	740,026	2,670,114	3,369,822	3,405,045	2,634,891

Notes: Authors' analysis using Vital Statistics & American Hospital Annual Survey Data 2007-2017. The outcomes in columns 1-9 are All, Black, White, Hispanic, Other-race, High Education, Low Education, Married, and Non-Married. The model controls for distance and different hospital quality metrics. A high-risk individual is a mother over the age of 44 years or that is beyond 35 years and have had a previous c-section, or had a c-section and a plural birth. The models also control for hospital size variables (different indicator for total hospital beds, outpatient visits, registered nurses and other personnels, number of registered nurses adjusted by the state scope of practice laws, number of maternity care providers with admitting privileges, and hospital total expenses), community characteristics (unemployment rate, Medicaid expansion, obstetric reimbursement rates, certificate of needs law, poverty rates, household income, and county population). The standard errors are clustered at the individual level. Coefficients from separate Multinomial Logit Models may be scaled differently. For a consistent interpretation, we compute the Willingness To Travel (WTT). See empirical section for more details about the WTT.

Table 4: Estimates of Marginal Utilities for Different Sub-Categories

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All	Teen	Young	Old	Medicaid	Private	Uninsured	Elective C-section	Induction of Labor
Distance Metrics									
Distance	-0.126***	-0.140***	-0.126***	-0.113***	-0.131***	-0.117***	-0.118***	-0.131***	-0.133***
	(0.000183)	(0.000506)	(0.000212)	(0.000541)	(0.000351)	(0.000349)	(0.00126)	(0.000481)	(0.000354)
Ghost County	-1.437***	-1.798***	-1.412***	-1.001***	-1.597***	-1.039***	-1.251***	-1.534***	-1.614***
	(0.0195)	(0.0525)	(0.0226)	(0.0592)	(0.0383)	(0.0408)	(0.131)	(0.0514)	(0.0376)
Hospital Quality									
Obstetric Beds	0.00387***	0.00354**	0.00404***	0.00328*	0.00135	0.00144	-0.000614	0.00332**	0.00229*
	(0.00061)	(0.00159)	(0.000712)	(0.00189)	(0.00120)	(0.00130)	(0.00469)	(0.00159)	(0.00118)
Bassinets	0.00521***	0.00632***	0.00499***	0.00500***	0.00643***	0.00522***	0.0120***	0.00536***	0.00630***
	(0.00063)	(0.00165)	(0.000725)	(0.00193)	(0.00119)	(0.00129)	(0.00448)	(0.00163)	(0.00120)
NICU	-0.38***	-0.339***	-0.361***	-0.526***	-0.346***	-0.397***	-0.0351	-0.394***	-0.327***
	(0.0134)	(0.0356)	(0.0154)	(0.0436)	(0.0252)	(0.0273)	(0.0918)	(0.0359)	(0.0257)
High-risk*NICU	0.769***	1.793***	1.206***	0.357***	0.738***	0.723***	0.549***	0.283***	0.416***
	(0.0211)	(0.107)	(0.0362)	(0.0348)	(0.0442)	(0.0372)	(0.141)	(0.0403)	(0.0716)
Accreditation	0.0573***	0.0554***	0.0629***	0.0242	0.0634***	0.0712***	0.185***	0.0507***	0.0568***
	(0.00065)	(0.0173)	(0.00755)	(0.0202)	(0.0122)	(0.0129)	(0.0466)	(0.0170)	(0.0124)
Major Teaching	-0.738***	-0.803***	-0.765***	-0.546***	-0.678***	-0.635***	-1.064**	-0.591***	-0.776***
	(0.0529)	(0.165)	(0.0611)	(0.138)	(0.0904)	(0.0796)	(0.435)	(0.136)	(0.105)
Minor Teaching	-0.105***	-0.0710**	-0.108***	-0.126***	-0.103***	-0.157***	-0.237***	-0.123***	-0.113***
	(0.0098)	(0.0280)	(0.0112)	(0.0291)	(0.0160)	(0.0162)	(0.0589)	(0.0256)	(0.0185)
Public	0.0724***	0.0284	0.0814***	0.0809***	0.0791***	0.143***	0.269***	0.0356	0.0708***
	(0.0089)	(0.0229)	(0.0104)	(0.0286)	(0.0167)	(0.0192)	(0.0650)	(0.0230)	(0.0170)
Non-Profit	0.157***	0.117***	0.165***	0.173***	0.160***	0.262***	0.243***	0.158***	0.167***
	(0.0.0084)	(0.0217)	(0.0218)	(0.0265)	(0.0157)	(0.0178)	(0.0611)	(0.0215)	(0.0158)
Low Quality									
Critical Access (CAH)	-0.144***	-0.132***	-0.149***	-0.120***	-0.166***	-0.182***	-0.255***	-0.128***	-0.142***
	(0.009)	(0.0249)	(0.0109)	(0.0292)	(0.0182)	(0.0189)	(0.0690)	(0.0244)	(0.0178)
Sole Community (SCH)	0.009	-0.00456	0.00457	0.0751**	-0.0229	-0.00688	-0.182***	-0.0200	-0.00873
	(0.0106)	(0.0289)	(0.0122)	(0.0320)	(0.0178)	(0.0189)	(0.0663)	(0.0276)	(0.0205)
Individual-Hospitals	113,488,826	18,419,249	84,437,831	10,631,746	33,238,899	26,710,979	3,458,884	17,577,151	33,259,427
Individual (births)	6,039,936	980,791	4,496,157	562,988	1,769,909	1,422,310	184,179	935,951	1,771,003

Notes: Authors' analysis using Vital Statistics & American Hospital Annual Survey Data 2007-2017. The outcomes in columns 1-9 are All, Teen (21 years or less of Age), Young (21-34 years), Old (35 and over), Medicaid insurance, Private insurance, Uninsured, Elective C-section, and Induction of Labor. The models control for distance and different hospital quality metrics. A high-risk individual is a mother over 44 years or that is beyond 35 years and have had a previous c-section, or that had a c-section and a plural birth. The models also control for hospital size variables (different indicator for total hospital beds, outpatient visits, registered nurses and other personnels, number of registered nurses adjusted by the state scope of practice laws, number of maternity care providers with admitting privileges, and hospital total expenses), community characteristics (unemployment rate, Medicaid expansion, obstetric reimbursement rates, certificate of needs law, poverty rates, household income, and county population). The standard errors are clustered at the individual level. Coefficients from separate Multinomial Logit Model may be scaled differently. For a consistent interpretation, we compute the Willingness To Travel (WTT). See the empirical section for more details about the WTT.

Table 5: Estimates of Marginal Utilities Using Lag Values for Quality Metrics

	Main Specification	Model With Lag Hospital Values
Distance Metrics		
Distance	-0.126***	-0.127***
	(0.000183)	(0.000184)
Ghost County	-1.437***	-1.563***
	(0.0195)	(0.0168)
Hospital Quality Metrics		
Obstetric beds	0.00387***	0.00377***
	(0.00061)	(0.000633)
Bassinets (beds for babies)	0.00521***	0.00469***
	(0.00063)	(0.000646)
Neonate Intensive Care Unit (NICU)	-0.38***	-0.297***
	(0.0134)	(0.0117)
High-risk*NICU	0.769***	0.770***
	(0.0211)	(0.0222)
Accredited Hospitals	0.0573***	0.0616***
	(0.00065)	(0.00652)
Major Teaching Hospitals	-0.738***	-0.777***
	(0.0529)	(0.0524)
Minor Teaching Hospitals	-0.105***	-0.0833***
	(0.0098)	(0.00921)
Public Hospitals	0.0724***	0.0713***
	(0.0089)	(0.00894)
Non-Profit Hospitals	0.157***	0.155***
	(0.0084)	(0.00838)
Hospital Low Quality Metrics		
Critical Access Hospitals	-0.144***	-0.145***
	(0.009)	(0.00926)
Sole Community Hospitals	0.009	0.0210**
	(0.0106)	(0.0104)
Individual-Hospitals	113,488,826	113,488,826
Individual	6,039,936	6,039,936

Notes: Authors' analysis using Vital Statistics & American Hospital Annual Survey Data for the years 2007-2017. Each column represents a different model. Each model controls for distance and different hospital quality metrics. A high-risk individual is a mother over the age of 44 years, or that is beyond 35 years and have had a previous c-section, or that had a c-section and a plural birth. The model also controls for hospital size variables (different indicator for total hospital beds, outpatient visits, registered nurses and other personnels, number of registered nurses adjusted by the state scope of practice laws, number of maternity care providers with admitting privileges, and hospital total expenses), community characteristics (unemployment rate, Medicaid expansion, obstetric reimbursement rates, certificate of needs law, poverty rates, household income, and county population). The standard errors are clustered at the individual level.

Table 6: Differences by Education and Health Insurance Status

	Low-Education&Medicaid	College-Education&Private-Insurance
Distance Metrics		
Distance	-0.135***	-0.114***
	(0.000451)	(0.000548)
Ghost County	-1.634***	-0.966***
	(0.0493)	(0.0637)
Hospital Quality Metrics		
Obstetric beds	0.00141	0.00303
	(0.00154)	(0.00203)
Bassinets (beds for babies)	0.00566***	0.00532***
	(0.00152)	(0.00201)
Neonate Intensive Care Unit	-0.370***	-0.397***
	(0.0326)	(0.0421)
High-risk*NICU	0.813***	0.577***
	(0.0591)	(0.0537)
Accredited Hospitals	0.0738***	0.0649***
	(0.0155)	(0.0205)
Major Teaching Hospitals	-0.754***	-0.496***
	(0.119)	(0.112)
Minor Teaching Hospitals	-0.0955***	-0.163***
	(0.0205)	(0.0254)
Public Hospitals	0.0877***	0.110***
	(0.0212)	(0.0308)
Non-Profit Hospitals	0.166***	0.237***
	(0.0199)	(0.0284)
Hospital Quality Metrics		
Critical Access Hospitals	-0.181***	-0.178***
	(0.0232)	(0.0301)
Sole Community Hospitals	-0.0229	0.0176
	(0.0226)	(0.0301)
Individual-Hospitals	21,749,109	10,135,710
Individual	1,208,284	563,095

Notes: Authors' analysis using Vital Statistics & American Hospital Annual Survey Data for the years 2007-2017. Each column represents a different model. The model controls for distance and different hospital quality metrics. A high-risk individual is a mother over the age of 44 years or that is beyond 35 years and have had a previous c-section, or a mother that had a c-section and a plural birth. The model also controls for hospital size variables (different indicators for total hospital beds, outpatient visits, registered nurses and other personnels, number of registered nurses adjusted by the state scope of practice laws, number of maternity care providers with admitting privileges, and hospital total expenses), community characteristics (unemployment rate, Medicaid expansion, obstetric reimbursement rates, certificate of needs law, poverty rates, household income, and county population). The standard errors are clustered at the individual level.

Table 7: Estimates of Marginal Utilities Using Different Choice Sets

	40-miles Radius	50-miles Radius	60-miles Radius
Distance Metrics			
Distance	-0.103***	-0.126***	-0.140***
	(0.000174)	(0.000183)	(0.000198)
Ghost County	-0.570***	-1.437***	-1.988***
	(0.0177)	(0.0195)	(0.0216)
Hospital Quality Metrics			
Obstetric beds	0.00636***	0.00387***	0.00419***
	(0.000553)	(0.00061)	(0.000665)
Bassinets (beds for babies)	0.00675***	0.00521***	0.00285***
	(0.000567)	(0.00063)	(0.000680)
Neonate Intensive Care Unit (NICU)	-0.443***	-0.38***	-0.383***
	(0.0124)	(0.0134)	(0.0146)
High-risk*NICU	0.839***	0.769***	0.750***
	(0.0192)	(0.0211)	(0.0240)
Accredited Hospitals	0.0620***	0.0573***	0.0331***
	(0.00602)	(0.00065)	(0.00706)
Major Teaching Hospitals	-1.011***	-0.738***	-0.704***
	(0.0547)	(0.0529)	(0.0554)
Minor Teaching Hospitals	-0.100***	-0.105***	-0.0814***
	(0.00892)	(0.0098)	(0.0106)
Public Hospitals	0.0918***	0.0724***	0.0405***
	(0.00825)	(0.0089)	(0.00969)
Non Profit Hospitals	0.187***	0.157***	0.141***
	(0.00772)	(0.0084)	(0.00907)
Hospital Low Quality Metrics			
Critical Access Hospitals	-0.166***	-0.144***	-0.108***
	(0.00870)	(0.009)	(0.0101)
Sole Community Hospitals	0.0142	0.009	-0.0203*
	(0.00950)	(0.0106)	(0.0117)
Individual-Hospitals	70,701,421	113,488,826	163,078,272
Individual	6,039,936	6,039,936	6,039,936
Average Number of Hospitals	12	18	27
Market Area Population Coverage	91.54%	93.3%	96.5%

Notes: Authors' analysis using Vital Statistics & American Hospital Annual Survey Data for the years 2007-2017. Each column represents a different model. The three columns are 40, 50, and 60 miles radius between the centroid of the county of residence and county of birth occurrence. A high-risk individual is a mother over the age of 44 years, or that is beyond 35 years and have had a previous c-section, or that had a c-section and a plural birth. The model also controls for hospital size variables (different indicator for total hospital beds, outpatient visits, registered nurses and other personnels, number of registered nurses adjusted by the state scope practice laws, number of maternity care providers with admitting privileges, and hospital total expenses), community characteristics (unemployment rate, Medicaid expansion, obstetric reimbursement rates, certificate of needs law, poverty rates, household income, and county population). The standard errors are clustered at the individual level. Coefficients from separate Multinomial Logit Model may be scaled differently. For a consistent interpretation, we compute the Willingness To Travel (WTT). See the empirical section for more details about the WTT.

9 Appendix A: Glossary and AHA Data-Cleaning Steps

9.1 Glossary

ACA Affordable Care Act

CAH Critical Access Hospital

CHIPRA Children Health Insurance Reauthorization Act

CON Certificate of Need Law

UCO Unborn Child Option

SCH Sole Community Hospital

MaTH Major Teaching Hospital

MiTH Minor Teaching Hospital

NICU Neonate Intensive Care Unit

SD Standard Deviation

WTT Willingness To Travel

9.2 AHA Data-Cleaning Steps For Missing Values in Responding Hospitals

In the AHA data covering the period 2007-2017, over 20% of the hospital reported missing values for the number of Neonate Intensive Care Unit beds. As it has been argued in Freedman et al. (2015), a hospital facility will often report missing values for the number of NICU beds for a particular year while reporting the same number of NICU beds before and after the missing. We carry forward the number of beds and fill almost all the missing values. Additionally, some of the remaining missings were filled with the previous year's values, regardless of the same number of beds before and after missing. For the remaining (0.98% of the total observation) missing values, if the hospital facility has zero obstetric beds and zero bassinets for a specific year, we impute zero for the number of NICU beds. This approach is effective for several reasons, including the fact that it takes time for hospitals size to change and the fact that we only consider an indicator variable of any NICU beds for our measure of quality.

For our accreditation indicator, we had the same type of reporting issues. About one-third of the hospitals had missing values for whether or not they were accredited by the Joint Commission for a specific year while reporting the same non-missing value one year before and one or several years after. Given that it unlikely that hospitals' accreditation status will be changing back and forth every other year, we fill the missing values by carrying forward the accreditation status. Over the sample period, 66% of the hospitals were accredited by the Joint Commission, which is similar to the 65% found in Lam et al. (2018). We also use the same methodology to solve some of the missing values of obstetric beds. However, when the number of obstetric beds is different for the year before and after a missing value, we impute the average hospital obstetric beds.