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Article

Racial and Ethnic Disparities in Maternal Treatment and Death: Evaluating the Role of Hospital and Physician Effects

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Abstract
Past work has documented disparities in medical treatment and health outcomes across racial and ethnic groups. In some instances, disparities persist beyond individual health risk factors and reveal underlying differences in the hospital facilities or the attending physicians that different patients tend to go to. In the case of maternal mortality and cesarean delivery, not only does the U.S. perform poorly on both measures, but also there exist racial and ethnic disparities in maternal treatment that lead to disadvantaged outcomes for vulnerable populations. By separately absorbing hospital and physician fixed effects, the contribution of both facility and practitioner variation to the present health disparities can be identified. Hospital variation maps to a significant portion of the racial disparity in cesarean delivery and the ethnic disparity in the induction of labor. Controlling for physician fixed effects explains some portion of the racial disparities in maternal mortality and cesarean delivery, all of the ethnic disparity in cesarean delivery, and some of both disparities in the induction of labor. These results suggest ample opportunities for targeted intervention to minimize the variation between physicians and hospitals in their approach to maternal care toward more equitable care provision.

Keywords: Maternal mortality, maternal health, health disparities, fixed effects

1. Introduction

Despite significant improvements in healthcare across the United States and the developed world over the last century, United States maternal mortality rates are by far the highest among its peer countries. In 2018, the United States reported 17 maternal deaths per 100,000 live births, about six times the rate in countries such as the Netherlands and New Zealand (Tikkanen et al., 2020). Within the U.S., there also exists a significant disadvantage in maternal outcomes for Black individuals and other minority populations within the country. In 2020, the U.S. National Vital Statistics System reported that within the United States, the maternal mortality rate for non-Hispanic Black women was 55.3 deaths per 100,000 live births, a value 2.9 times the rate experienced by non-Hispanic white women (Hoyert, 2022). While the overall maternal mortality rate for Hispanic populations is not as disparate from that of non-Hispanic white populations, both racial and ethnic disparities in maternal treatment are similarly disparate.

The United States operates a hybrid health system consisting of publicly financed health coverage like Medicare and Medicaid, privately financed coverage like private health insurance, and out-of-pocket payments ("US Healthcare System"). Similarly, hospitals receive both public and private funding in amounts based upon the specific condition or treatment of a given patient ("US Healthcare System"). Because complicated and varied health schemes overlap with social concepts like race and other cultural and political institutions, causes of racial and ethnic disparities are inherently difficult to identify and eradicate. The United States has not only higher rates of unhealthy behaviors in calorie consumption and drug misuse but also maintains a built environment that discourages physical health and is racially and socioeconomically segregated (Crear-Perry et al., 2021). The difference in maternal mortality and treatment outcomes between racial and ethnic groups could arise due to differences in observed characteristics. Comorbidities and disease incidence tend to impact vulnerable populations at higher rates, placing them at higher risk for health complications (Ahmed et al., 2020). Beyond individually observable conditions like obesity or Medicaid coverage, disparities in health outcomes could emerge from differences in treatment patterns. Individuals of different racial and ethnic groups may seek–or be able to seek–treatment at starkly different facilities or from different healthcare professionals. Many individuals in the United States suffer due to the inaccessibility of care whether due to financial limitations or a dearth of primary care providers (Crear-Perry et al., 2021). The impacts on health outcomes of lower income, insurance coverage, and lack of access to care reveal the poverty-related limitations disproportionately felt by communities of color. Between healthcare facilities like hospitals, even if the medical practitioners themselves are similar, access to resources and funding, as well as institutional practices, could impact treatment practices. If it is the case that physicians themselves are fundamentally different, variation in cultural competency or implicit bias could impact the treatment of vulnerable populations.

Previous studies have explored to what extent observed characteristics determine health disparities. Ultimately, individual-level variation in medical risk factors, income, educational attainment, and insurance status do not explain the extent of health access, treatment, and outcome disparities across racial and ethnic cohorts (Gavin et al., 2004; Kirby et al., 2006). Others have shown that Black and Hispanic patients are treated at lower-performing hospitals and that hospital variation contributes to disparities in mortality (Chandra et al., 2020). Similarly, physician biases in diagnosis and treatment determinations can impact Black patients' health outcomes, including survival (Eli et al., 2019). Other literature analyzes both contributing factors in hospital and physician variation, attempting to explain disparities in the mortality treatment patterns of racial groups (Greenwood et al., 2020; Lee et al., 2019; Peterson et al., 1994; He et al., 2012; Popescu et al., 2016; Barnato et al., 2006). Overall, there is well-documented descriptive work of disparities in health and ample

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efforts to identify their point of emergence within the healthcare system for multiple health concerns. However, no study has tested physician and hospital variation to determine their contribution to well-established disparities in maternal treatment and outcomes for racial and ethnic cohorts.

I begin to identify the ways in which racial and ethnic disparities emerge in the United States healthcare system by disentangling the roles of hospital-level variation and physician-level variation in maternal death, cesarean delivery, and the induction of labor. Using Florida inpatient hospital census data of individual-level hospitalization instances from 2006 to 2014, I use multiple linear probability models which exploit variation in race and ethnicity among patient observations to estimate the disparate rates of maternal death non-Hispanic Black, non-Hispanic white, and Hispanic population cohorts. Two nearly identical models use the same changes in race and ethnicity to estimate the disparities in instances of cesarean delivery and the induction of labor in the sample. By absorbing fixed effects for hospitals and physicians separately in each of these estimations and controlling for individual characteristics including comorbidities, age, insurance status, and socioeconomic status (SES) indicators in recorded zip code, I identify the partial contribution of hospitals and physicians toward the observed racial and ethnic disparities in maternal health. In the identification of the level, hospital or physician, at which these disparities emerge, there arise opportunities for eliminating the preventable deaths of Black mothers. Whether by altering hospital culture and funding allotments or transforming physician training practices, targeted interventions can attempt to minimize emergent disparities. If patients nonrandomly sort to hospitals and physicians, then variation in hospitals and physicians will explain some portion of racial and ethnic disparities in maternal death and treatment.

2. Background

2.1. Racial Disputes

Despite the tremendous improvements in healthcare and health outcomes in the U.S. over the past century and a quarter, not all groups of the population experienced the same level of benefit. Racial and ethnic inequalities that permeate the United States' economy, society, and culture also appear in healthcare access, treatment, and outcomes. Racialization and ethnicization are processes that ascribe social meaning to observable characteristics. Historically, as those social meanings are assigned, hierarchies emerge in which dominant groups are able to maintain power and as a result, constraints exert themselves on the resource access of socially devalued groups (Hicken et al., 2018). One such social constraint lies in the creation of generalized archetypes such as a Black individual who has engaged with the criminal justice system or a Hispanic individual who is an undocumented immigrant. This type of cultural stereotyping formulates "spillover effects" that impact other members of the social group through stigmatization and resultant implicit biases (Hicken et al., 2018). Racial and ethnic biases in research and practice recommendations, especially in the field of healthcare, are characterized by a lack of individuals of color as subjects and participants as institutions of higher education systematically exclude people of minority backgrounds (Graves, 2019).

In healthcare, vulnerable populations are described as "social groups who experience limited resources and consequent high relative risk for morbidity and premature mortality" (Flaskerud, 1998). Thus, as resource access and biases combine to create disadvantaged health outcomes for vulnerable populations, race and ethnicity have real biological effects not because of true genetic or natural differences, but because of socially constructed and maintained differences. Those socially constructed and maintained differences in U.S. culture have their deep roots in the time of slavery

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when our nation's institutions were being built upon the assumed supremacy of dominant white male landowners. For vulnerable populations today, modern day health disparities partially arise from practices built upon ideologies of racial difference originating from a time when Black individuals were not recognized as genetic or social equals. The idea that black people have lower lung capacity, higher heat and pain tolerance, higher disease tolerance, and mental deficiency have very serious effects as doctors tend to treat patients differently according to these implicit biases (Hammonds et al., 2019). While more recent years have called more direct attention to racial and ethnic disparities in healthcare, the 2002 Kaiser Family Foundation National Survey of Physicians found that a majority of doctors say that the healthcare system rarely (55%) or never (14%) treats people differently based upon racial or ethnic background ("National Survey", 2002). When considering well-documented differences in treatment, it becomes evident that implicit bias remains an aspect of healthcare influencing today's disparate outcomes for vulnerable populations.

2.2. Racism in Maternal Healthcare

Specifically in the field of obstetrics and gynecology (OBGYN), its founding and development with early researchers relied on experimentation on enslaved women, seeking to control their reproduction (Rubashkin, 2022). These origins in subjugation create a systemic and lasting bias against communities of color and other vulnerable populations that are forced to exist within systems built upon their exploitation. For example, the National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network formulated a decision-making algorithm based upon the probable success of a vaginal birth after a cesarean delivery (VBAC), which is a decision that arises when a birthing mother previously underwent a primary cesarean and may be a candidate for a subsequent vaginal birth. It is a national public health interest to increase successful VBACs because multiple surgical births are riskier for the mother (Rubashkin, 2022). The VBAC algorithm automatically predicts approximately half of the probable success for minority women, assuming intrinsic racial differences and ignoring the fact that racism and biases, not race and ethnicity themselves, generates disparate health outcomes (Grobman et al., 2007). Even in removing the explicit discount for Black and Hispanic women, they are differentially likely to be subject to the delivery via cesarean when comorbidity incidence rates like obesity and hypertension rates are differentially high among minority populations. It is important to note that in the case of maternal morbidity–health problems arising from pregnancy and childbirth–racial and ethnic disparities in maternal health treatment patterns seem to transcend any socially disparate instances of comorbidities (Admon et al., 2018).

On a global scale, the Millennium Development Goals put forth by the United Nations sought to reduce maternal mortality by 75% by 2015 (MacDorman et al., 2016). Despite these international healthcare development ideals, the maternal mortality rate in the United States has increased in recent years, and, in fact, the unadjusted rate of maternal mortality more than doubled between 2000 and 2014 (MacDorman et al., 2016). A portion of these increases arise from changes in reporting seeking to make the collection of maternal mortality data more accurate, but even when accounting for previous underreporting, there exists a 26.6% increase in maternal mortality between 2000 and 2014 (MacDorman et al., 2016). The present racial and ethnic imbalances in healthcare and health outcomes are glaringly evident in the disparities defined in measured maternal mortality and maternal care outcomes. Further, in comparing the maternal mortality rates between 2019 and 2020, the increases in rate for non-Hispanic Black women was statistically significant while the relatively smaller increases experienced by non-Hispanic white women were not significant (Hoyert, 2022).

Figure 1 displays the mortality due to pregnancy, childbirth, and the puerperium, which is the period of six weeks following childbirth, per 100,000 live births by race according to compressed mortality data by the Centers for Disease Control and Prevention ("Compressed Mortality File", 1980; "National Vital Statistics" 1980). Over the forty years reported, the mortality rate remained constant until 2000, at

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which point it began increasing. The rate of Black mortality in Figure 1 is significantly greater than that of white populations, and in recent years, it increased at an accelerated rate.

Figure 2 displays these same mortality measurements for Hispanic and non-Hispanic white groups ("Compressed Mortality File", 1999; "National Vital Statistics" 1980). Collection of data on ethnicity began in 1998 in the U.S., so Figure 2 describes Hispanic and non-Hispanic mortality rates from 1999 until 2020. In 2000, the mortality rates due to pregnancy, childbirth, and the puerperium were nearly identical but subsequently began to diverge over the following decades. Contrary to the divergent increase in Black population mortality, the mortality rates of Hispanic people increase at a slower rate as compared to those of non-Hispanic white populations. This parallels the "Hispanic health paradox" which describes the fact that Hispanic people in the U.S. tend to experience health outcomes in parity with or better than other social groups in measures of life expectancy, infant mortality, cancer morbidity, and other health measures despite having lower income and lower rates of insurance coverage (Fernandez et al., 2023). On a national scale, a younger age at childbirth for Hispanic parents and lower rates of engagement in risky health behaviors like smoking could contribute to these mortality outcomes (Fernandez et al., 2023).

Like the United States' shortcomings in maternal mortality, "the primary cesarean rate was 21.5% in 2005 and the overall rate reached 32.9% in 2009" (Solheim et al., 2011). These rates greatly exceed the maximum 15% cesarean rate recommended by the World Health Organization (Solheim et al., 2011). Delivery via cesarean raises the relative risk of maternal mortality, and Black and Hispanic patients have much higher rates of delivery by cesarean. In 2021, 30.8% of births to white patients were cesarean deliveries as compared to 31.3% of deliveries to Hispanic patients and 36.2% for Black patients ("Final Natality", 2021). Another common treatment in labor management is the induction of labor (IOL), which includes the rupturing of membranes or medical or surgical intervention to initiate labor. Like cesarean delivery, the rates of IOL are stratified by racial and ethnic groups. Black and other minority patients have lower rates of IOL than white populations, as shown in a 2021 study which found that in the U.S., 27.2% of Black patients experienced IOL compared to 32.5% of white patients (Singh et al., 2018; Wang et al., 2021). Though the medical necessity of IOL in varying contexts of parental age, gestational age, and other characteristics should be considered by medical practitioners, the general professional guidelines suggest that IOL can be used to reduce the likelihood of cesarean delivery (Hamm et al., 2020). So, it is evident that racial and ethnic differences in the rates of both cesarean delivery and IOL align with other documented health disparities in treatment and outcomes.

3. Literature Review

In this study, I focus on identifying the contribution of hospitals and physicians to the present racial and ethnic disparity in maternal death, cesarean delivery, and IOL. While little research exists surrounding maternal health beyond the provision of summary statistics, previous literature has identified the contribution of hospital variation and physician bias to disparities in other health outcomes. Using Medicare hospitalization records and enrollment records, one study establishes a method of measuring hospital performance using survival rates and calculates that rate for Black and white populations (Chandra et al., 2020). They then demonstrate that Black heart attack patients go to lower performing hospitals even when living in the same Hospital Referral Region as comparable white patients. The racial disparity in outcomes has been diminishing in more recent years with improvements characterized by the adoption of technologically advanced treatment techniques concentrated at low performing hospitals treating mostly Black patients (Chandra et al., 2020). A separate study estimates the racial disparity in lifespan outcomes for Union Army veterans by exploiting existing variation in physician disability ratings in their determinations which impact disability insurance provision. Their work confirms an impact of physician attitudes on racial disparities in health based upon the fabricated ideas of the inferiority of the Black body and of the

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lesser status of symptoms experienced by those bodies, significantly impacting the outcomes of health concerns which are difficult to uniformly diagnose (Eli et al., 2019).

There is also evidence that utilizes a census of patients admitted to hospitals in the state of Florida that includes individual-level data on race, comorbidities, and patient outcomes, as well as hospital and physician identifiers. The data confirm a disadvantage in mortality for Black mothers, and specifically that Black mothers attended by white physicians "experience an additional 14 deaths per 100,000 births, tripling white mothers' mortality rate of 7 per 100,000 births" (Greenwood et al., 2020). Despite this documented disparity, racial concordance does not provide statistically significant change in mortality for Black mothers.

Another group of studies attempt to identify the emergence of racial disparities in the intensity of treatment for various health issues. Lee et al. (2019) explores the effect of being from a minority group on the use of pain treatment medications for acute pain presentations in emergency department settings. They find that Black patients and Hispanic patients were less likely than white patients to receive equivalent pain management use. Peterson et al. (1994) find that Black patients with acute myocardial infarction are less likely to undergo intensive treatment. He et al. (2012) update and expand upon these findings and demonstrate that controlling for hospital and physician fixed effects can explain the Hispanic-white disparities and some of the Black-white disparities existing across surgical treatment techniques for patients experiencing acute myocardial infarction. They outline many of the avenues by which such racial and ethnic disparities may emerge at either the hospital or physician level as minority patients may obtain treatment from specific hospitals or physicians via mutual selection. The control variables utilized in their model are paragon as they not only match patient discharge to socioeconomic status data for further individual-level controls, but they also match hospital identifiers to factors such as hospital ownership type and teaching status.

Similarly, Popescu et al. (2016) suggest that a portion of the racial and ethnic disparities present in care for colorectal and breast cancer patients is attributable to physician-level variation. Using physician fixed effects in a logistic model to evaluate the effects of race, ethnicity, and socioeconomic status on cancer care quality, the study found that minority and low socioeconomic status patients are less likely to receive any of the recommended cancer treatments. Barnato et al. (2006) use a similar fixed-effect model to study terminal admissions across multiple states, arguing that racial disparities in individual treatment preferences cannot create all of the disparity in end-of-life care since preferences rarely map to exact treatment outcomes. They demonstrate that racial and ethnic disparities in end-of-life care emerge from hospital-level variation in ICU use, and those differences do not emerge within hospitals themselves. In accordance with this body of literature which utilizes hospital and physician variation to identify their relative contribution to disparate treatment and mortality outcomes along lines of race and ethnicity in pain management, AMI, cancer, and end-of-life care, I evaluate these hospital- and physician-level contributions toward racial and ethnic disparities in maternal death, caesarean delivery occurrence, and IOL.

4. Data

This study uses hospital inpatient census data from 2006 to 2014 from the Agency for Health Care Administration in the state of Florida. Each record has data on patient race, ethnicity, age, zip code, principal payer, procedures performed, neonatal ICU charges, up to thirty comorbidities, and the disposition of the discharge (e.g., patient discharged to home, transferred to another hospital, patient

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expired, etc.). The sample was limited to patients who delivered a child during that time period[1]. I further limited the sample to patients whose race was either Black or white or whose ethnicity was Hispanic. These sample limitations yielded a sample of 1,589,374 hospitalization instances for analysis. The key explanatory variable is based upon the patient's race and ethnicity to create population cohorts of non-Hispanic Black patients, Hispanic patients, and non-Hispanic white patients.

The outcomes of interest are whether the patient died in the hospital, whether the delivery was by cesarean section or there was IOL. Maternal death occurrence is defined by the discharge status of, which provides a limited definition of maternal mortality that does not include patients who die outside of the hospital or in subsequent hospitalizations. Cesarean delivery occurrence is obtained from the Medicare diagnosis-related group (DRG) (Fingar, 2006) and the applicable procedure codes according to the International Classification of Disease Vol. 3 Procedure Codes (ICD-9-CM) ("ICD-9-CM Diagnosis")[2]. Similarly, IOL occurrence is obtained from the procedure codes of ICD-9-CM ("ICD-9-CM Diagnosis")[3].

I utilized numerous control variables from the individual-level hospital records for the resulting multivariate analysis. I used a continuous measure of age to account for the relationship between increasing age and increasing maternal mortality and treatment interventions. Similarly, age-squared accounts for the fact that the impact of age on outcomes of interest may vary over the range of ages in the sample. I controlled for certain comorbidities that play a role in maternal mortality and treatment outcomes including obesity, diabetes, hypertension, asthma, hypothyroidism, cord complications and smoking. I created indicator variables for each instance of these comorbidities according to their ICD-9 diagnosis codes ("ICD-9-CM Diagnosis"). Additionally, I controlled for time-variant effects using indicator variables for the quarter and year of the hospitalization instance.

I used each patient's zip code of residence to match each hospitalization record with median household income using data from the American Community Survey administered by the U.S. Census Bureau. This serves as a continuous measure of socioeconomic status of patients at the zip code-level since personal income data is not attainable. The American Community Survey data did not include zip code-level median household income prior to 2011. Since the data at this level of geography is only available as a five-year average and zip code-level socioeconomic indicators are unlikely to dramatically change within a short period, I used the 2011 median household income across the entire sample.

A unique feature of the Florida inpatient dataset is that it has a code for each facility and attending physician, and I used these codes to control for hospital and physician fixed effects. The facility code is the Agency for Health Care Administration facility number which allowed me to then match each record to observed hospital characteristics using the Centers for Medicare & Medicaid Services Provider of

[1] Patients who delivered a child during that time period are identified by the patients that experienced charges for labor and delivery room services according to revenue codes 720 through 729 outlined by UB-02 and UB-04 and used for uniform medical billing across medical institutions.
[2] DRG codes were recorded until the fourth quarter of 2007 when the records were refined to groupings according to Medicare Severity (MS) DRG codes. Cesarean delivery occurrences are identified by DRG 370 and 371 prior to 2007, by MS-DRG 765 and 766 after 2007, and by ICD-9-CM 74.00-74.99 for the entire time period.
[3] IOL occurrences are identified by ICD-9-CM 73.00-73.99 for the entire time period.

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Service 2011 dataset ("The Provider of Services", 2011). From this data, I obtain hospital-level urbanity, ownership, and bed count.[4]

5. Methods

I used Stata/BE 17.0 as an analysis software to perform a multivariate analysis using a set of twelve linear probability models with varying fixed effect controls to estimate the marginal effects of group-specificity on outcomes of interest. The central estimating equation takes the form of a linear probability model illustrated by equation [1].

$$Y_{ihpq} = \beta_0 + race_{ihpq}\beta_1 + ethnicity_{ihpq}\beta_2 + X_{ihpq}\beta_3 + \lambda_q + \epsilon_{ihpq} \qquad [1]$$

The outcome variable of interest Y_{ihpq} takes the form of an indicator variable whether individual *i* in a hospital *h* with an attending physician *p* in year and quarter *q* expired in the recorded hospitalization. The same applies for an outcome variable of interest in which the indicator variable Y_{ihpq} describes cesarean delivery or IOL at the same levels of specificity. Therefore, I estimated this equation separately for three different outcome variables. The explanatory variable $race_{ihpq}$ is a binary variable indicating whether an individual *i* in a hospital *h* with an attending physician *p* in year and quarter *q* is Black, and $ethnicity_{ihpq}$ is a binary variable indicating whether an individual *i* in a hospital *h* with an attending physician *p* in year and quarter *q* is Hispanic. X_{ihpq} a large set of individual-level characteristics for age, zip code-level median household income, primary payer, length of hospital stay, and seven comorbidities associated with maternal health. λ_q controls for the time-variant fixed effects associated with all patients each year and quarter time frame. ϵ_{ihpq} is the idiosyncratic error term which catches all other unobserved characteristics. Overall, β_1 and β_2 are the estimated coefficients of interest which represents the baseline linear probability outcomes, or the marginal effect of an individual patient being Black or Hispanic on mortality, cesarean delivery, and IOL outcomes. This coefficient was later compared to the coefficient of interest arising from equations [2] and [3] which control for hospital and physician fixed effects, respectively, in either race or ethnicity population cohort.

I estimated a nearly identical linear probability model with the addition of hospital fixed effects as encapsulated by equation [2].

$$Y_{ihpq} = \delta_0 + race_{ihpq}\delta_1 + ethnicity_{ihpq}\delta_2 + X_{ihpq}\delta_2 + \alpha_h + \lambda_q + \epsilon_{ihpq} \qquad [2]$$

These hospital fixed effects are described by α_h and in appending them to [1], I am able to absorb all time-invariant characteristics shared by all patients with a hospitalization instance at a given hospital *h*,

[4] Not all facility numbers in the Florida data matched to a Medicaid or Medicare vendor number, so hospital-level monthly live birth records and facility county were used to match facilities to likely vendor numbers ("Table 14A").

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including variables that are unobserved in the data. Equation [2] continues to control for individual characteristics (X_{ihpq}) and time-variant effects (λ_q). The estimated coefficients of interest are δ_1 and δ_2 which describes the marginal effect of an individual patient being Black or Hispanic on mortality, cesarean delivery, and IOL outcomes when controlling for hospital fixed effects.

Third, I estimated another nearly identical linear probability model substituting hospital fixed effects for physician fixed effects shown by equation [3].

$$Y_{ihpq} = \gamma_0 + race_{ihpq}\gamma_1 + ethnicity_{ihpq}\gamma_2 + X_{ihpq}\gamma_3 + \theta_p + \lambda_q + \epsilon_{ihpq} \qquad [3]$$

The physician fixed effects are described by θ_p and control for all time-invariant characteristics associated with a specific physician *p* which would impact all outcomes of patients seen by that physician, including those unobservable in the data. Equation [3] continues to control for individual characteristics (X_{ihpq}) and time-variant effects (λ_q). The estimated coefficients of interest are γ_1 and γ_2 which describes the marginal effect of an individual patient being Black or Hispanic on mortality, cesarean delivery, and IOL outcomes when controlling for physician fixed effects.

Finally, I estimated a model intended for comparison with equation [2] in which the hospital fixed effects, which control for all time-invariant hospital characteristics both observable and unobservable, are replaced with observable hospital characteristics. This linear probability model is described by equation [4].

$$Y_{ihpq} = \mu_0 + race_{ihpq}\mu_1 + ethnicity_{ihpq}\mu_2 + X_{ihpq}\mu_3 + \Psi_h\mu_4 + \lambda_q + \epsilon_{ihpq} \qquad [4]$$

Ψ_h is a large set of hospital-level characteristics for facility bed count, urbanity, hospital ownership status, and the presence of a neonatal ICU level I, II, or III. Equation [4] continues to control for individual characteristics (X_{ihpq}) and time-variant effects (λ_q). The estimated coefficients of interest are μ_1 and μ_2 which describe the marginal effect of an individual patient being Black or Hispanic on mortality, cesarean delivery, and IOL outcomes when controlling for observable hospital characteristics.

6. Results

6.1. Descriptive

Table 1 provides the means of variables of interest for the full sample and by race and ethnicity cohorts. As is displayed, the full sample is made up of 1,589,374 patients. There are 809,898 non-Hispanic white patients (51.0%), 387,609 non-Hispanic Black patients (24.4%), and 391,867 Hispanic patients (24.7%). The rates of mortality, cesarean delivery, and IOL suggest racial disparities in all outcomes of interest and ethnic disparities in cesarean delivery and IOL. Across the entire timeframe of the sample, the rate of maternal mortality for non-Hispanic white patients is 0.0054%, 0.0165% for non-Hispanic Black patients, and 0.0046% for Hispanic patients. In this sample, Black patients are much more likely to die in childbirth as indicated by the present odds ratio of approximately 3.2. Figure 3 describes these rates of maternal death in terms of deaths per 100,000 live births across the entire time frame. These rates of maternal death are lower than the U.S. rates for the same timeframe displayed in Figure 1 because the measure of maternal death in these estimates only catch deaths that occur immediately in the initial hospitalization. Figure 4 shows the rates of cesarean delivery for all three population cohorts, and Figure 5 shows the rates of IOL for the same cohorts. Both figures indicate that the difference between the rates of non-Hispanic Black patients and Hispanic patients are significantly different from those of non-Hispanic white patients.

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The remaining content of Table 1 summarizes differences in patient characteristics by race and ethnicity. There is a statistically significant difference in all variables listed except for diabetes in Hispanic populations, which trends similarly to non-Hispanic white populations in this sample. Overall, this suggests that non-Hispanic Black and Hispanic patients are slightly younger, have lower median household income, experience longer hospital stays, and are more likely to be on Medicaid or be self-payers than non-Hispanic white patients. Similarly, non-Hispanic Black patients are more likely to be obese, have diabetes, have hypothyroidism, and have asthma than white patients. Non-Hispanic white patients are more likely to have commercial insurance coverage, experience cord complications, smoke, and have hypertension.

Overall, the rates of the comorbidities related to pregnancy and birth risks are much lower in this sample than are found in the broader population. The Pregnancy Risk Assessment Monitoring System (PRAMS) is a state-level surveillance system of maternal health behaviours that seeks to inform prenatal health programs ("Florida Pregnancy"). In the state of Florida, the PRAMS trends over the period 2000 until 2011 found rates of obesity to be near 30% among non-Hispanic Black patients and 20% among non-Hispanic white and Hispanic patients, which are significantly higher than the rates of obesity observed in the Florida inpatient census. Not only did the Florida PRAMS data show that non-Hispanic Black patients experienced a higher prevalence of obesity and other comorbidities than non-Hispanic white patients and Hispanic patients, but it also found later entry into prenatal care and lower infant birth weights among that cohort ("Florida Pregnancy").

Because patients from different population cohorts may interact differently with hospitals and physicians, I provide some summarization of the hospitals and physicians within the sample. There are a total of 131 unique hospitals and 4,158 unique physicians, and many physicians see patients at multiple hospitals. This signals that the hospital fixed effects relate to physician fixed effects by providing fixed effects at a more aggregate scale. Similarly, there are 1,225 physicians that only see white patients, 502 physicians that only see Black patients, and 343 physicians only see Hispanic patients. Most of these hospitals and physicians that are only related to one race are only linked to one or very few patients, so this should be understood in describing the hospital and physician data.

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Table 1. Descriptive Statistics for Full Sample and by Population Cohort

Variable	Non-Hispanic White	Non-Hispanic Black	Hispanic	Full Sample
Maternal Death	0.0000543	0.000165***	0.0000459	0.0000793
Cesarean Delivery	0.277	0.287***	0.309***	0.288
Induced Labor	0.676	0.660***	0.653***	0.666
Age	27.89	26.04***	27.53***	27.35
Median Household Income	51237.0	41814.6***	47428.7***	48006.9
Obesity	0.0248	0.0454***	0.0242*	0.0297
Diabetes	0.00696	0.0123***	0.00707	0.00829
Hypothyroidism	0.00576	0.0163***	0.00532***	0.0153
Asthma	0.0318	0.0364***	0.0258***	0.0314
Hypertension	0.0204	0.00488***	0.0148***	0.00822
Smoking	0.00719	0.00222***	0.000972***	0.00444
Cord Complications	0.226	0.193***	0.212***	0.214
Length of Stay	2.612	2.930***	2.685***	2.708
Medicaid	0.414	0.679***	0.591***	0.524
Commercial Insurance	0.518	0.249***	0.298***	0.398
Self-pay	0.0295	0.0329***	0.0674***	0.0397
N	809,898	387,609	391,867	1,589,374

*Statistically significant differences in mean between NH Black and NH white or between Hispanic and NH white indicated by *** for .01, ** for 0.05, * for .10.*

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Table 2. Baseline Linear Probability Model Estimations of Outcomes of Interest

Explanatory Variables	Maternal Mortality	Cesarean Delivery	Induction of Labor
Patient Characteristics			
NH Black	0.0000238	0.0144***	-0.0258***
	(0.0000185)	(0.000909)	(0.000957)
Hispanic	-0.0000315*	0.0383***	-0.0314***
	(0.0000180)	(0.000881)	(0.000928)
Age	-0.000338***	0.0112***	-0.00268***
	(0.00000830)	(0.000408)	(0.000430)
Age-squared	0.00000610***	-0.0000452***	-0.0000883***
	(0.000000100)	(0.00000710)	(0.00000740)
Median Household Inc	-7.25E-10	0.0000001**	-0.0000003***
	(0)	(0)	(0)
Obesity	0.0000156	0.189***	-0.111***
	(0.0000425)	(0.00208)	(0.00220)
Diabetes	0.000424***	0.109***	-0.165***
	(0.0000794)	(0.00389)	(0.00410)
Hypertension	0.000774***	0.0802***	-0.0819***
	(0.0000800)	(0.00392)	(0.00413)
Asthma	-0.0000184	0.00921***	0.00228
	(0.0000409)	(0.00201)	(0.00211)
Hypothyroidism	-0.0000246	0.0264***	-0.0107***
	(0.0000585)	(0.00287)	(0.00302)
Cord Complications	-0.00000630	-0.0720***	0.116***
	(0.0000174)	(0.000852)	(0.000898)
Smoking	0.000441***	0.00168	-0.0265***
	(0.000109)	(0.00532)	(0.00561)
Length of Stay	0.000141***	0.0344***	-0.0240***
	(0.00000300)	(0.000147)	(0.000155)
Insurance Status			
Medicaid	0.00000900	-0.0202***	0.0260***
	(0.0000169)	(0.000830)	(0.000875)
Medicare	0.00104***	-0.0504***	-0.0303***
	(0.0000921)	(0.00452)	(0.00476)
TriCare/Federal Gov	0.0000687	-0.0523***	0.0211***
	(0.0000560)	(0.00275)	(0.00289)
Veterans Affairs	-0.0000660	-0.0593***	0.0704***

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	(0.000230)	(0.0113)	(0.0119)
Table 2 cont.			
Other State/Local Gov	-0.0000266	-0.0824***	0.0843***
	(0.000126)	(0.00616)	(0.00649)
Self pay	0.000663*	-0.0819***	0.0481***
	(0.0000386)	(0.00189)	(0.00199)
Non-payment	-0.0000181	-0.0395***	0.0521***
	(0.0000855)	(0.00419)	(0.00442)
Kidcare	-0.00043	0.0306***	-0.0229*
	(0.000238)	(0.0117)	(0.0123)
Commercial Liability	-0.000147	-0.00826	-0.206***
	(0.000539)	(0.0264)	(0.0278)
Workers' Comp	-0.000291	-0.204***	-0.0971
	(0.00143)	(0.0700)	(0.0738)
Other	0.000242	-0.0388***	0.0161**
	(0.000153)	(0.00751)	(0.00791)

*Notes: All models also include year-quarter fixed effects. The omitted categories are white non-Hispanics, patients with no comorbidities, and commercial insurance. Standard errors reported in parentheses *** p<.01, ** p<.05, * p<.1*

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6.2. Regression Results

Table 2 reports results from estimating equation [1], specifying the marginal impact of non- Hispanic Black race and Hispanic ethnicity on three outcomes of interest while controlling for patient characteristics including patient age, median household income, comorbidities, and insurance status. The coefficients of interest, those on non-Hispanic Black and Hispanic cohorts, serve as baseline estimations or the estimated disparities in mortality and treatment in the sample. The disparities between non-Hispanic white and non-Hispanic Black populations in both cesarean delivery and IOL are persistent through all controls and statistically significant to the 1% level. Black race increases the likelihood of cesarean delivery by 1.44 percentage point which is a 5.20% change from the rate of cesarean delivery of white patients. For IOL, Black race decreases the likelihood by 2.58 percentage point which is a 3.82% decrease from the rate of IOL for white patients. While not statistically significant in this sample, Black race increases the likelihood of maternal death by 0.0024 percentage points which equates to a 43.8% increase from the rate of maternal death among white patients.

For Hispanic populations, the likelihood of mortality decreases by 0.003 percentage points which is a 55.1% decrease from the non-Hispanic white cohort. Their likelihood of cesarean delivery is 3.83 percentage points higher which is an 13.8% increase from the non-Hispanic white rate. Hispanic ethnicity decreases IOL by 3.14 percentage points which is a 4.64% decrease from the non-Hispanic white rate of IOL. Across the sample, having Medicare coverage or being a self-payer increases the likelihood of mortality. Nearly all insurance coverage, in comparison to commercial insurance, decreases the likelihood of cesarean delivery, and most primary payers, except Medicare, increase the likelihood of IOL. This pattern could be observed due to the payment structure in the U.S. healthcare system where intrapartum payments vary by insurance coverage. One study found that in 2010, the average commercial intrapartum payment for cesarean births was nearly three times that of Medicaid intrapartum cesarean birth payments (Corry, 2013). It is also important to note that the Medicare births are rare because the only patients under the age of 65 on Medicare would be those with social security disability insurance coverage. The associations between comorbidities and the outcomes of interest show that most comorbidities increase the likelihood of mortality and cesarean delivery while they decrease the likelihood of IOL. Similarly, mortality outcomes seem to be worse for the youngest and oldest patients.

Table 3 attempts to delineate the between- and within-provider differences in maternal treatment and outcomes by race and ethnicity. For each outcome, I display the coefficient for non- Hispanic Black or Hispanic as I begin with baseline models and move onto models with more controls. There are three panels: results for maternal mortality (Panel I), cesarean delivery (Panel II), and IOL (Panel III). Within each panel, I display the raw differences between the non-Hispanic white cohort and either the non-Hispanic Black cohort or the Hispanic cohort (row a) as well as the results of estimating equations [1] through [4] (rows b-e). Table 3 reiterates the baseline estimations for all outcomes of interest and allows for their comparison to the effects of being Black or Hispanic on maternal mortality, cesarean delivery, and IOL when hospital fixed effects or physician fixed effects are absorbed within the model. The models including fixed effects also include the full set of controls as described by equations [2] and [3], but those coefficients are not reported for presentation and comparison purposes.

In comparing rows (a) and (b) in Panel I, observed patient characteristics explain most of the racial disparity in maternal mortality. Examining a pattern of results when hospital (row c) and physician fixed effects (row e) are added suggest that the non-random sort of patients into providers explains little of the disparity once individual controls are added (row b). The unexpected increase in the Black coefficient in absorbing hospital fixed effects is likely because Black patients go to hospitals with low rates of maternal mortality even if the racial cohort experiences differentially higher rates of mortality. By comparing Hispanic patients to non-Hispanic white patients in column (2) of Panel I, the modest benefit of being Hispanic on maternal mortality increases once observable patient characteristics are included in the model (row b). This suggests that even though Hispanic patients generally have worse observed patient

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characteristics than non-Hispanic white patients, they are less likely to die. Adding hospital fixed effects or controls for observable hospital characteristics does not alter the ethnic difference, but when physician fixed effects are absorbed, the negative coefficient is largely eliminated. This suggests that Hispanic patients visit physicians that have better than average outcomes in terms of maternal mortality as compared to the physicians that non-Hispanic white patients visit.

By comparing coefficients in Panel II, I estimate the effect of absorbing fixed effects on disparities in cesarean delivery. Rows (a) and (b) in both columns (1) and (2) demonstrate that with even with observed patient characteristic controls, Black and Hispanic patients are still more likely to experience cesarean delivery. When hospital fixed effects (row c) are absorbed, the positive coefficient that demonstrated a baseline racial disparity (row b) when controlling for observed patient characteristics is mostly eliminated. This suggests that the non-random sort of Black patients to hospitals explains a significant portion of the racial disparity in cesarean delivery. Because observed hospital characteristic controls do not reflect the same results as controlling for hospital fixed effects, it appears that unobservable hospital characteristics account for more of the racial disparity in cesarean delivery. Similarly, adding physician fixed effects (row e) eliminates the positive coefficient in column (2) of Panel II, suggesting that the non-random sort of patients to physicians explains a significant portion of the ethnic disparity in cesarean delivery. More specifically, the absorption of hospital fixed effects accounts for 89.1% of the initially reported racial disparity, and the absorption of physician fixed effects diminishes the marginal effect of being Hispanic by 99.8%.

For IOL, rows (a) and (b) in both columns (1) and (2) of Panel III demonstrate that even after controlling for observed patient characteristic controls, Black and Hispanic patients remain less likely to experience IOL than non-Hispanic white patients. By absorbing hospital fixed effects (row c), the racial disparity decreases 72.7% and the ethnic disparity decreases 93.3% to a less significant disparity. This suggests that, particularly for Hispanic patients, the non-random sorting of Black and Hispanic patients to hospitals explains a portion of the cohort’s disparity in IOL. Similarly, the absorption of physician fixed effects (row e) decreases the racial disparity by 63.3% and the ethnic disparity by 85.8%. Although the non-random sorting of Black and Hispanic patients to physicians explains some part of the disparities in IOL, none of these fixed effect controls render the disparities insignificant from non-Hispanic white rates of IOL.

Across all panels, the estimates of equation [4] are displayed in row (d) where only observed hospital characteristics are used as hospital-level controls in place of hospital fixed effects. This evaluates to what extent such observable characteristics account for disparities in all three outcomes.

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Table 3. Linear Probability Model Estimations, With and Without Absorption of Hospital and Physician Fixed Effects

Population Cohort	(1) Non-Hispanic Black	(2) Hispanic
Panel I. Maternal Mortality		
(a) Raw Differences	0.0111***	-0.000839
	(0.00222)	(0.00136)
(b) Baseline model estimations	0.00238	-0.00315*
	(0.00185)	(0.00180)
(c) Absorbing hospital fixed effects	0.00288	-0.00286
	(0.00199)	(0.00204)
(d) Baseline with observed hospital characteristics	0.00287	-0.00244
	(0.00188)	(0.00183)
(e) Absorbing physician fixed effects	0.00442**	-0.000680
	(0.00183)	(0.00189)
Panel II. Cesarean Delivery		
(a) Raw Differences	1.00***	3.13***
	(0.0881)	(0.0890)
(b) Baseline model estimations	1.44***	3.83***
	(0.0909)	(0.0881)
(c) Absorbing hospital fixed effects	0.157*	0.409***
	(0.0949)	(0.0972)
(d) Baseline with observed hospital characteristics	1.02***	3.07***
	(0.0916)	(0.0894)
(e) Absorbing physician fixed effects	0.371***	0.00820
	(0.0960)	(0.0992)
Panel III. Induction of Labor		
(a) Raw Differences	-1.65***	-2.32***
	(0.0922)	(0.0921)
(b) Baseline model estimations	-2.58***	-3.14***
	(0.0957)	(0.0928)
(c) Absorbing hospital fixed effects	-0.704***	-0.210**
	(0.100)	(0.103)
(d) Baseline with observed hospital characteristics	-2.59***	-2.67***
	(0.0965)	(0.0942)
(e) Absorbing physician fixed effects	-0.946***	-0.447***
	(0.101)	(0.105)

*Notes: Raw Differences display the difference in outcomes rates between the minority sample and the white sample. All coefficients have been multiplied by 100 to report as percentage points. Standard errors reported in parentheses *** p<.01, ** p<.05, * p<.1*

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Table 4. Hospital Characteristics for Full Sample and by Population Cohort

Variable	Non-Hispanic White	Non-Hispanic Black	Hispanic	Full Sample
Bed Count	621.0	747.3***	764.4***	687.2
By urbanicity				
Urban	0.963	0.983***	0.979***	0.972
Rural	0.037	0.017***	0.021***	0.028
By ownership type				
Church Ownership	0.067	0.068	0.047***	0.062
Not for Profit	0.426	0.380***	0.483***	0.429
For Profit	0.224	0.219***	0.199***	0.216
Public	0.194	0.261***	0.206***	0.213
By Neonatal ICU				
No NICU	0.294	0.370***	0.427***	0.345
NICU Level I or II	0.427	0.300***	0.275***	0.359
NICU Level III	0.279	0.330***	0.298***	0.296
By volume of births in sample				
Low Volume	0.083	0.043***	0.050***	0.065
Medium Volume	0.295	0.249***	0.248***	0.272
High Volume	0.622	0.708***	0.701***	0.663
N	809,898	387,609	391,867	1,589,374

*Statistically significant differences in mean between NH Black and NH white or between Hispanic and NH white indicated by *** for .01, ** for 0.05, * for .10.*

In both cesarean delivery and IOL rates, these observed characteristics of hospitals decrease both the racial and ethnic disparities but to a lesser extent than the absorption of hospital fixed effects. Table 4 provides the descriptive statistics of observable hospital characteristics included in the estimation of equation [4]. All observable hospital characteristics are statistically significant in comparing the hospitals Black and Hispanic patients go to with those of non-Hispanic white patients, except for church ownership where Black and white patients are equally likely to find themselves treated. Black and Hispanic patients are more likely to go to more urban hospitals, hospitals with higher bed counts, public hospitals, hospitals lacking a NICU, and hospitals with higher volumes of births. Again, these observable hospital characteristics do not account for much of the racial and ethnic disparities even though there are significant differences in the hospitals the population cohorts are likely to go to.

Table 5 displays further analysis which ran equation [1] for all three outcomes of interest for three groups based upon the percent of patients on Medicaid in each hospital facility. In general, the percent of patients on Medicaid at a given facility can feasibly represent the socioeconomic status of the surrounding area. So, facilities with a low percentage of patients on Medicaid are likely to exist in areas of higher wealth. The results suggest that Black patients who go to facilities where either low or high percentages of

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patients are on Medicaid have better maternal mortality outcomes. For cesarean delivery rates, both Black and Hispanic patients do significantly better in terms of having lower rates of cesarean delivery in hospitals where more patients are on Medicaid. Hispanic patients have an extremely high increase in cesarean delivery in wealthier area facilities but have lower rates of cesarean delivery in hospitals where most patients are on Medicaid. IOL outcomes follow a similar pattern in that they are also worse for both Black and Hispanic patients in wealthier areas but are improved among facilities with a high percentage of patients on Medicaid.

6.3. Discussion and Conclusion

In this paper, I examine whether the non-random sorting of Black and Hispanic patients to hospitals and physicians can explain disparities in maternal care and outcomes. I find that hospital- level variation explains most of the racial disparity in cesarean delivery and some of both the racial and ethnic disparities in cesarean delivery and IOL. Physician-level variation, then, accounts for most of the ethnic disparity in cesarean delivery and some of both the racial and ethnic disparities in cesarean delivery and IOL. In terms of maternal mortality, much of the racial disparity remains unexplained by provider variation which suggests that the hospitals and physicians that treat Black patients are not directly causing disparities in maternal mortality within the sample. Because observed patient characteristics explain nearly all of the racial disparity in maternal mortality, even in a sample where health risk-related comorbidities are underrepresented, there may be inequities that lie beyond the scope of provider differences that contribute to racially disparate measures of maternal mortality.

These results suggest that the differences between hospitals and physicians which treat patients of different cohorts can explain a significant portion of the differential rate of maternal treatment for Black and Hispanic patients. Therefore, the way in which patients are matched to hospitals and physicians for treatment does, in fact, contribute to the racial and ethnic disparities in cesarean delivery and IOL. Despite decreases in disparate rates for these treatment outcomes with fixed effect absorption, differences between hospitals and between physicians persist for all outcomes of interest except for with hospital-level variation and the racial disparity in cesarean delivery as well as physician-level variation and the ethnic disparity in cesarean delivery.

The data used to construct these results present certain limitations to their validity. Because the available Florida inpatient dataset recorded by the Agency for Health Care Administration is administrative records that lack personally identifiable information, patients could not be matched to entire medical histories which might detail comorbidities not reported in the sample hospitalizations. The rates of all comorbidities are incredibly low and do not parallel much of the rates found in the U.S. population which suggests that underreporting of health risk factors is a significant problem in Florida hospital records for births.

Similarly, observations could not be matched to specific individual characteristics beyond what the administrative hospital records report. This means that the socioeconomic status indicator used, median household income within the patient's recorded zip code of residence, may not accurately represent the true socioeconomic status of patients. There were many observations missing median household income due to missing data in patient zip code, including those of any patients born outside the U.S., which is particularly important in a setting like Florida where immigrant populations that may identify as Black or Hispanic are likely to be large. As the income-health association is widely confirmed, there may be impacts of socioeconomic status on all outcomes of interest for which the models fail to control. Further, maternal death is generally defined to be death during pregnancy or within 42 days of the end of the pregnancy ("Maternal Deaths"). Because the sample observations cannot be matched to other

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hospitalizations, I do not account for any maternal deaths that occur prior to the childbirth hospitalization or following that initial hospitalization.

The results of the models controlling for physician fixed effects are threatened by the nonuniformity of risk within the occurrence of childbirth. Since some physicians who are specialists may tend to see higher risk patients–which is more likely for Black or Hispanic patients–they would be linked to higher rates of mortality and cesarean delivery. The models attempt to control for this by using length of stay as a patient characteristic control. Patients who experience complications, especially in a cesarean delivery, will remain in the hospital longer, but this may not control for all instances of birth complication.

Because my focus lies in the Black-white and Hispanic-non-Hispanic disparities, these results do not apply to other racial disparities that exist in maternal mortality and cesarean delivery occurrence. This prompts further study to determine how hospital and physician variation contribute to racial and ethnic disparities which may disadvantage Asian, Native American and Alaskan Native, and Native Hawaiian or Pacific Islander social groups.

My findings point toward the need for interventions at both the hospital and physician level to improve maternal treatment and outcomes for Black and Hispanic patients. Because hospital variation contributes to a significant portion of the racial disparity in cesarean delivery and of the ethnic disparity in IOL, improvements in resource quality and access aimed at promoting vaginal birth with IOL when it is medically favorable could be directed toward facilities which tend to treat Black and Hispanic patients. Additionally, medical facilities might have an opportunity to establish hospital-wide policies limiting the use of the racialized VBAC algorithm in favor of unbiased methods. Since observed hospital characteristics did not explain disparities to the same extent that the absorption of hospital fixed effects did, it is likely that unobserved hospital characteristics are more responsible for racial and ethnic disparities in health. This means that less measurable elements like staff quality, management styles, institution ethos, and practice patterns may play a larger role in emergent health disparities. These elements are difficult to measure, but they are not unchangeable. Efforts to alter unobserved characteristics will require more intentioned efforts to target facility-wide culture and practices. Further, in the supplemental analysis using percent of patients on Medicaid as a proxy for the wealth of a facility's surrounding area, treatment outcomes are significantly worse for minority patients in wealthier areas. Therefore, it is necessary to pursue a more equitable distribution of funding and resources not only between facilities which serve different social cohorts but also between social cohorts at a given facility.

Similarly, since physician variation explains nearly all the ethnic disparity in cesarean delivery, a portion of the racial disparity in cesarean delivery, and a portion both disparities in IOL, there needs to be further examination into how these disparities manifest across physicians. Policymakers, medical facilities, and physicians themselves can minimize the variation between physicians in their treatment of maternal health. Specifically, policymakers might reevaluate the ways in which physicians are compensated for certain procedures to better direct their decision-making in maternal treatment. Facilities might implement programs which seek to minimize implicit biases within their physicians. My results not only establish that racial and ethnic disparities persist in maternal death, cesarean delivery, and IOL and prompt further investigation of the emergence of these disparities but also suggest the existence of possible solutions toward equity in decreasing the effects of institutionalized racism within the U.S. healthcare system.

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