SPATIAL ANALYSIS OF BIRTH CENTER LOCATIONS AND SERVICE CATCHMENT AREAS IN THE CONTIGUOUS UNITED STATES: AN APPLICATION OF PUBLIC HEALTH CRITICAL RACE PRAXIS

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Objectives: Birth center care is associated with improved health for childbearing people of all racial or socioeconomic groups. Black people are underrepresented among birth center clientele and the midwifery workforce. This is troublesome given the legacy of Black midwives in the United States (US), who were systematically disenfranchised by the obstetrical field in the late 19th and early 20th centuries. Applying Public Health Critical Race Praxis, the objectives of this dissertation research are to examine the distribution of birth center locations in the contiguous US, describe their service communities, and explore how structural racism (e.g., employment inequity) influences access to birth center care for Black childbearing people.

Methods: Leveraging secondary data, this research applied spatial analytic methods to illustrate birth center locations and assess spatial clustering (i.e., global and local Moran's I) of states and counties with birth centers. This dissertation also investigated the association between quantitative measures of structural racism and the presence of birth centers using multivariable logistic regression; and compared childbearing populations within birth center catchment areas to those outside.

Results: Global Moran's I testing indicated significant spatial autocorrelation of counties with birth centers, including by attribute (e.g., accreditation). Multivariable regression demonstrated significantly higher odds of birth center presence at the county level with increased racial segregation and increased racial inequity regarding educational attainment, controlling for

population size and midwifery scope. Compared to childbearing populations outside, those within birth center catchment areas had significantly larger proportions identifying as Asian, Black, and Hispanic.

Conclusions: Gaps in birth center locations appear in the South and Midwest, as well as in less urbanized counties with lower population sizes. Associations between racial inequity and birth center presence underscore the impact of structural racism on perinatal health. Birth center catchment areas are demographically diverse, contrasting the homogenous samples documented in the literature.

Public Health Significance: The childbearing populations within the catchment areas of existing birth centers are more racially heterogenous compared to the make-up of clientele cited in the evidence base, highlighting the need for further research to examine the drivers of racially disparate engagement with birth center care.

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Preface

Public Health Critical Race Praxis implores the researcher to engage in self-reflection and critique. For me, this means claiming my personal stake in studying birth center access for Black childbearing people, a population of which I am not a part.

Before graduate school, I worked at The Midwife Center (TMC) in the Strip District neighborhood of Pittsburgh. Established in 1982, TMC is one of the oldest birth centers in the country. During my time there as an administrator, I quickly learned that the birth center world is overwhelmingly White and upper class. This led me to consider how birth centers are still vulnerable to the oppressive forces that impact the entire healthcare field, regardless of investment in serving all childbearing people and applying a patient-centered model of care. Entering my doctoral studies, I sought more knowledge about disparities in reproductive health, particularly in the birth center context, and the tools best suited to narrow these gaps.

1.0 INTRODUCTION

The United States (US) exhibits persistent disparate rates of adverse perinatal outcomes between Black and White childbearing people, with the former group experiencing the highest rates of pregnancy-related mortality (e.g., due to cardiovascular condition, pre-existing illness) and infant mortality (death before one year of age) compared to all other racial and ethnic groups.[1] Recent data from the Centers for Disease Control and Prevention (CDC) show an infant mortality rate of 10.8 and 4.6 deaths per 1,000 live births for non-Hispanic Black people and non-Hispanic Whites, respectively, representing a Black-White ratio of approximately 2.3.[2] The CDC also reported a pregnancy-related mortality rate of 42.4 deaths per 100,000 live births among Black childbearing people between the years 2011-2016, compared to 13.0 per 100,000 for White birthing people.[3] In 2020, the first full year of the COVID-19 pandemic, the US saw a surge in pregnancy-related mortality; the rate climbed about 26% for non-Hispanic Black people and 7% for non-Hispanic White people, representing an 18% increase in the overall Black-White disparity.[4] The decades-long trend of Black childbearing people experiencing high rates of infant mortality and pregnancy-related mortality, typically three to four times the rates among Whites, begs urgently for interventions tailored to this population from public health officials and policymakers.

A potential strategy to improve outcomes for Black childbearing people and their infants is increased access to birth center care across the US. Birth centers emerged as alternative sites for giving birth in the 1970s, providing home-like birthing environments, apart from tertiary care units (e.g., hospitals, NICUs). Still today, most birth centers are freestanding, managed by professional midwives who apply a wellness- and person-centered care model that encourages and emphasizes

the client's participation in health decision-making.[5-7] Over the last 40 years, research has demonstrated that birth center care is associated with considerably better outcomes for childbearing people of all socioeconomic and racial groups compared to national statistics.[6-9] Landmark national studies of birth center outcomes have demonstrated considerably lower rates of low birthweight infants (LBW: < 2,500 grams at birth), preterm birth (PTB: birth at < 37 weeks' gestation), and cesarean birth, when compared to matched cohorts receiving conventional, hospital-based care.[6,9,10] An estimated 85% of childbearing individuals are eligible for birth center, in the absence of medical risk factors indicated before (e.g., chronic hypertension, diabetes) and during pregnancy (e.g., multiple gestation, pre-eclampsia).[6] Given that birth centers are typically led by midwives, often with the consultation of collaborating physicians, the literature attributes these improvements to elements unique to the midwifery care model, such as increased time spent with providers, emphasis on perinatal education and shared decision-making, and application of evidence-based interventions only when indicated.[8,11]

The current evidence to gauge Black people's access to birth center care is limited. Recent multi-center studies indicate that Black clients represented an estimated 5.5% of a national sample registered for care and eligible for birth center birth and an estimated 11.9% of a sample of Medicaid beneficiaries, despite representing about 15% of the childbearing population in the US.[6,8] Given the evidence that these settings consistently produce optimal outcomes for their clients, it is a public health research imperative to understand population-level access to this model, as well as why some childbearing individuals may not be able to achieve access. To be clear, this paper conceptualizes access to care based on the definition from Healthy People 2020, which encompasses insurance coverage and consuming health services in a timely manner from a trustworthy care provider.[12]

The perinatal care environment includes the clinicians charged with supporting a childbearing person during pregnancy and labor, making the backgrounds and behaviors of birth center midwives relevant to studying clients' access. Even as the US population has become more racially and ethnically diverse over the last 20 years, the midwifery workforce has remained more than 90% White.[13] The most recent report from the Accreditation Commission for Midwifery Education indicates a diversifying student body, based on enrollment data for Master's and doctoral level midwifery education programs.[14] However, no published reports exist detailing the demographics of midwives that practice at birth centers. Recent literature describes the goals and perceptions of Black midwives working in these settings, including their desire to revive the legacy of Black midwives as experts in pregnancy and birth.[15-17]

Community birth – giving birth at a home or in a community setting – was the norm in the US until the late 19th century, with midwives being the main care providers.[18] Black midwives held important roles in providing birth care for nearly all childbearing people in the southern US for centuries, extending into the mid-1900s, as well as in apprenticing future midwives.[19] Even so, the state-sanctioned elevation of White male physicians as medical authorities in the late 19th and early 20th centuries instigated the subsequent ousting of Black midwives from mainstream practice.[13,18,19] Given this history in midwifery and community birth, the current racial homogeneity of midwives and their clients is especially troublesome and deserving of targeted investigation.

From the era of slavery through the late 20th century, the largely White public health and medical fields in the US neglected the needs of Black populations at best and exploited them at worst.[20,21] In addition to normalized forms of anti-Black racism, including physical and sexual violence, public health and medical professionals historically attributed poor health among Black

people to their racial inferiority, particularly in comparison to Whites.[20-23] The documented study of racial disparities in health outcomes emerged in the 1990s, with social epidemiologists identifying and assessing contextual factors that differentially impact racial groups after controlling for other known covariates.[21,22,24] The concept of social determinants of health (SDOH), or place-based circumstances that impact a person's wellness and health risk, advocated that researchers consider environmental exposures in the study of public health.[25] Specific to reproductive health, the field saw the development of theoretical frameworks, such as the weathering hypothesis,[26] that helped to explain how context-based exposures over the life course, such as experiences with interpersonal racism, impact a person's physical and mental health. Recent calls for perinatal interventions that go beyond the childbearing individual have focused on the roles of neighborhoods[27-29]; race- and gender-based discrimination,[30-32] and culturally informed, person-centered health care.[16,23,33,34]

Evidence demonstrating heterogeneity in perinatal outcomes for Black childbearing people at state, regional, and county levels[35-37] further underscores the importance of context in studying these outcomes in general, and the Black-White disparities in particular. In their state-level analysis of Black infant mortality rates and the Black-White infant mortality ratio, Brown Speights, et al.[35] demonstrated that many states are failing to advance toward racial equity, despite achieving reductions in Black infant mortality over time. In addition, research examining social factors at the regional level (e.g., Black-White marriage rate) demonstrated relative risk reduction in the Black infant mortality rate in some US regions, but not in others.[36] The impact of geography becomes even more relevant in the context of licensure for obstetric facilities and providers, including birth centers and midwives, which differs by state.[38-40]

1.1 THEORETICAL FRAMEWORKS

1.1.1 Public Health Critical Race Praxis

This research applies principles of Public Health Critical Race Praxis (PHCR) in its discussion of Black-White disparities in perinatal health and care access, including low representation of Black birth center clients, by situating these circumstances within the larger context of Black subjugation at the hands of Whites and obstetrical professionalism in the 19th and 20th centuries. PHCRP extends the theoretical application of Critical Race Theory by positioning exposure to racism as a health risk rather than racial identity and emphasizing the importance of context when addressing race-based health inequities.[41] In addition to naming racism as a risk factor for oppressed populations, PHCRP highlights the normalization of Whiteness in the public health and medical fields, which has served to elevate White professionals over all others.[41]

Guided by PHCRP, this research acknowledges that anti-Black racism infiltrates not only care delivery and outcomes but also the study of perinatal health and the disparities therein. The framework encompasses four separate but related focuses of racial consciousness (Figure 1).[41] Starting with contemporary racial relations, Focus 1 prompts the question of how racism is operating in a context, including quantitative and qualitative descriptions of oppression and discrimination at all socioecological levels, from the individual to the societal.[41] Focus 1 applies to the current, persistent racial disparities in perinatal-related and infant mortality, which affect Black people disproportionately,[42,43] and the systemic forms of oppression that contribute to these disparities.[23,44,45] Furthermore, Focus 1 applies to the current state of birth centers in the US, where staff people are majority White and reflect their largely White clientele, with minimal published literature addressing the issue of access for Black childbearing people.

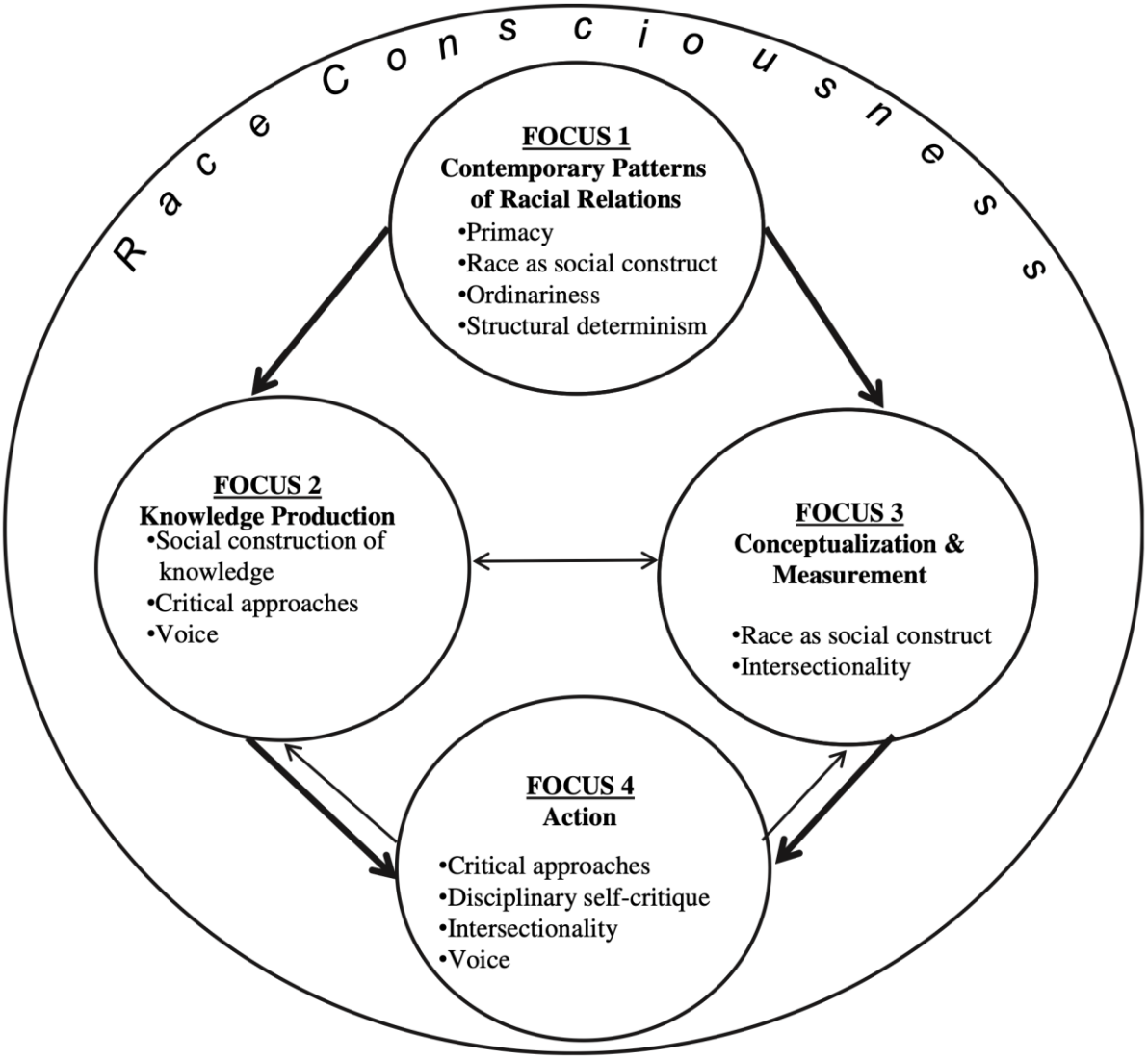

Figure 1. Figure pulled from Ford & Airhihenbuwa, 2010, illustrating the four focuses of racial consciousness and ten related principles.

Focus 2, knowledge production, goes beyond contributing to the body of research regarding a race-based health inequity by highlighting the social construction of scientific knowledge, rather than presenting findings as objectively discovered fact.[41] As discussed earlier, the growing professionalism in the medical field in the early 20th century mirrored the racial segregation and discrimination at play throughout the US, consequently disenfranchising

experienced Black midwives and negating their legacy of providing safe, accessible birth care to their communities.[19] The current landscape of midwifery and community birth in the US, including scientific study of health outcomes related to these models, reflects this racialized historical erasure. National studies[6,8] reporting on perinatal and infant outcomes in birth centers may stratify samples by race to describe client demographics, but this literature seemingly assumes that clients' care experiences do not vary by race or other demographic attributes. By intentionally centering Black clients in the scientific study of birth centers and associated outcomes, researchers can simultaneously produce new knowledge and recognize the bias of existing knowledge.

Focus 3 of PHCRP, conceptualization and measurement, emphasizes the social construction of racial identities, inviting researchers to apply an intersectional approach to the study of health and disease.[41] Case in point: increased socioeconomic status for Black childbearing people does not play the same protective role against adverse perinatal outcomes as it does for their White counterparts.[46-48] In addition, geography has greatly influenced the historical trajectory of midwifery, prenatal care, and physician-managed birth.[19,38,49] The demonstrated geographic variation in Black-White disparities in birth outcome[35,45] further obliges an intersectional approach in the study of access to birth centers, which operate according to state licensure requirements.

Focus 4 is singularly represented by the word "action." With the scientific study of race-based inequities in health, including access to care, must come the aim to "disrupt one or more causes of the inequities[41-1393]". Broadening the scope of birth center research beyond comparisons with hospital birth outcomes permits the consideration of contextual factors associated with access to that care model. Rather than facilitating behavioral interventions at the individual level, assessing the influence of environmental and contextual factors presents actionable opportunities

to better inform standard operating procedures for care providers and improve policy measures that affect childbearing people and their families.

1.1.2 Aligning tenets of the midwifery model

Although Black childbearing people engage with midwifery and birth center care at a disproportionately low rate, this research assumes that this population desires these services for three reasons. First, the limited literature exploring these issues does not indicate racially differential perceptions of community birth. One multi-site, cross-sectional study demonstrated that Black people report viewing community birth just as positively as White people.[50] Another study examined racial differences in perspectives on vaginal versus surgical birth, and the investigators found no significant differences between Black and White participants.[51]

Secondly, as described previously, Black midwives in the US persisted in their tradition and involvement in birth practices for centuries.[19,49,52] They often extended these services and expert knowledge to White people, not only caring for White birthing people but also by cooperating with White physicians, nurses, and public health practitioners in an attempt to coalesce midwifery practice with newly professionalized obstetrical science.[19] Although overall demand for modern midwifery and birth center services did not surge in the US until the 1970s, Black midwives and their predecessors continued contributing to this legacy before and throughout the 20th century, overcoming racialized persecution at community and professional levels. Due to systemic racial disparities in perinatal care access, encompassing the intersections of socioeconomic factors (e.g., insurance coverage, childcare affordability) and discriminatory biases embedded in the medical field, not all Black childbearing people who desire midwifery and birth center services can benefit from this legacy and actualize this care.

Lastly, many of the preferences in reproductive care reported by Black childbearing people link directly to tenets of midwifery care and community birth. In addition to affordability of care, Black birthing people highly value trust and mutual respect in their relationships with providers.[34,53-56] Research on clinical outcomes and patient experience over the last several decades has consistently demonstrated the underserved nature of the Black population in the US. Midwifery care is not only associated with better outcomes but also with better care experiences, particularly among underserved groups.[18] Midwives have been lauded for their culturally sensitive approaches to care, which Karbeah, et al.[17] recently described as acknowledging a childbearing individual's expertise and "self-knowing" regarding pregnancy and birth, as well as allowing them to engage in familiar cultural practices, even if unfamiliar to the provider. Current evidence indicates that Black childbearing people are more likely to report inadequate care, or even mistreatment at the hands of providers, compared to Whites.[56,57] Hardeman, Karbeah and Kozhimannil[58] explain the health benefits of care grounded in trusting relationships and the importance of approaching pregnant individuals as experts about their own bodies.

1.2 OUTCOMES AND ACCESS FOR BLACK CHILDBEARING PEOPLE

1.2.1 Historical subjugation and intergenerational trauma

To better understand the role that birth center care can play in addressing poor reproductive health outcomes for Black Americans, we must explore the history of pregnancy and labor care in the United States. Critical to this is the impact of historical subjugation of Black childbearing populations. This history includes discriminatory policies (e.g., GI bill, redlining) that provided

financial benefits to White people while systematically withholding them from Black people fitting the same eligibility criteria. In turn, Black populations had diminished access to income and housing resources, resulting in intergenerational poverty over decades since the emancipation of Black slaves in 1865.[20,21,59]

People of African descent have experienced mistreatment, abuse, and exploitation for much of the 400-year period since chattel slavery first appeared in the US.[20,21] This includes the legal, sexual, and reproductive exploitation of enslaved Black women, where slave owners impeded their sexual autonomy and/or forced them to undergo experimental medical procedures.[20] Even after the emancipation of slaves in the US in 1865, Black people repeatedly faced the threat of violence from Whites.[20] During the Jim Crow Era (1865-1965), when openly anti-Black sentiment was still prevalent among politicians and other authority figures, Black women were not equally protected by law enforcement from assault, rape, or lynching.[20] Eugenic programs were also on the rise at the beginning of the 20th century, with academic scholars, scientists, and physicians supporting since-debunked research on how White people (European descent) were physically and mentally superior to other racial and ethnic groups.[60,61] In many states, eugenicist research and practice resulted in the involuntary sterilization of thousands of Black, Latino, and Indigenous childbearing people,[60-62] further deepening the historical divide between these oppressed groups and medical care providers.

When considering other social determinants related to poor health in the US, such as educational attainment, employment, geographic isolation, hazardous environmental exposures, and incarceration,[25] and how these intersect with racial inequities, the contemporary barriers to a healthy pregnancy and birth for Black childbearing people are further complicated. By studying or serving this population without acknowledging these historical influences, researchers and

practitioners fail to grasp the similarities between past and present oppressions, and thus how these exposures are related to modern trends in adverse health outcomes.[20]

1.2.2 Trends in adverse perinatal outcomes for Black people

Robust evidence shows that while the infant mortality rate has decreased substantially over the last 40 years for all racial groups, the Black-White disparity has remained relatively stable.[35,43,44,63,64] Vital records show that the Black-White ratio for infant mortality never rose above 1.95 between 1965 and 1980.[22] Since then, the Black-White ratio has steadily increased, peaking at almost 2.5 in the late 1990s.[43] In addition to the Reconstruction era 10 years after the US Civil War ended, researchers consider the civil rights era in the 1960s as a brief period where Black people saw improved access to health care and reductions in adverse health outcomes.[21] In 1965, the US saw the passage of the Civil Rights Act and subsequent desegregation of major institutions, and landmark Medicare/Medicaid legislation that expanded healthcare access for the poor and elderly.[21] However, by the late 1980s, the Department of Health and Human Services reported persistent racial disparities in health, even in the context of overall improvements regarding certain health indicators, such as the infant mortality rate.[22]

Several studies examining perinatal health disparities, specifically between Black and White populations, have shown that Black childbearing people experience higher risk even after controlling for known confounders at the individual level, such as age or tobacco use.[42,45,46,65] Using data from over 2.5 million birth certificates in 2016, Thoma, et al. demonstrated that Black-White disparities in preterm birth persisted after controlling for sociodemographic (e.g., education, US nativity, Medicaid insurance) and geographic (e.g., state of residence, county population size) characteristics.[45] Similarly, Leonard, et al. conducted a multi-year study of birth certificate data

that indicated a 27% higher risk of severe maternal morbidity (e.g., due to hemorrhage, stroke) among non-Hispanic Black people compared to Whites, adjusting for known clinical (e.g., previous surgical birth, anemia) and sociodemographic covariates.[42] To be clear, the CDC defines pregnancy-related death as one occurring during pregnancy or within a year after the end of pregnancy, due to issues directly related to or exacerbated by the pregnancy.[3]

Recent evidence demonstrates variation in perinatal outcomes for Black childbearing people at different geographic levels.[35-37] A state-level analysis of Black infant mortality rates and the Black-White infant mortality ratio showed how many states are failing to advance toward racial equity, despite achieving reductions in Black infant mortality over time.[35] In addition, research examining social factors at the regional level (e.g., Black-White marriage rate) has exhibited reduced relative risk for the Black infant mortality rate in some US regions but not in others.[36]

1.2.3 Current research in Black perinatal health

In the study of perinatal health, individual-level factors (e.g., exercise, nutrition, substance use) related to adverse perinatal outcomes have remained the dominant focus of research efforts and interventions over the last 20 years,[23] despite evidence that these factors only partially explain the racial disparities. By omitting the influences of factors beyond the individual level, researchers place the entire burden of behavioral or environmental change to reduce risk of adverse outcomes on the childbearing person, which is known as the "mother blame" narrative.[23] For many Black birthing people, this blame is amplified by their experiences of gendered racism and other race-related social inequities that inhibit them from improving their health or general circumstances.[23,66]

Improving perinatal outcomes in the US and reducing the race-based disparities therein requires innovative epidemiological research that goes beyond individual risk factors and

addresses systemic and contextual factors. In their 2014 analysis of vital statistics data over 19 years, Elder, et al. demonstrated that while the association between medical risk factors and infant death was decreasing, the "unexplained gap" between infant mortality rates for Black and White individuals persisted even when accounting for gestational age and birth weight.[44] Vital statistics data indicate parallel racial disparities in rates of PTB and LBW, two leading causes of infant mortality.[44,63,65] Some research illustrates a narrowing Black-White disparity regarding preterm birth, but this is attributed to overall increasing PTB rates among both racial groups.[45] In 2019, investigators estimated that 38% of the Black-White disparity in PTB was explained by individual-level covariate differences (e.g., sociodemographic characteristics and health behaviors), further emphasizing the need to address the factors that remain unexplored.[45] As a potential explanation for this improvement in outcomes alongside persistent or widening disparities, research suggests that progress in social benefits (e.g., Medicaid expansion) and beneficial interventions (e.g., medically induced preterm birth) have not been equitably distributed across all racial and socioeconomic groups.[64]

1.3 MIDWIFERY AND COMMUNITY BIRTH IN THE UNITED STATES

1.3.1 Professionalization of obstetrics in the 20th century

Two major legislative milestones shaped the fate of perinatal care and education in the 20th century, consequently changing the trajectory of midwifery care and community birth. First, the overhaul of medical education in the US is attributed to the Flexner Report in 1910, which outlined a plan for full-time education of medical practitioners and thus the transfer of established

physicians from clinical care settings to academia and scientific experimentation.[67] Critics have argued that this professionalization of medicine resulted in degradation of the patient experience and the profession "losing its soul[67-274]". In contrast to the apprenticeship structure of community midwives throughout the 19th century and into the early 20th century, when the passing down of knowledge and experience served as the primary method of education,[18] this approach in medical training programs centered on standards set by state licensure requirements. The shift in obstetrical training and licensure not only burdened established midwives with associated financial obligations but also disrupted the collaborative and mutually empowering midwifery approach.[49]

In this vein, the passing of the Sheppard-Towner law in 1921 facilitated major changes regarding the medical education of practitioners, including midwives, and provided additional funds to facilitate these programs.[49,52] Legislators' aim was to define and implement a national standard for maternity care to which providers would adhere, and funds were distributed to train midwives using this model.[18,52,68] Collaborative midwife practices emerged in the first half of the 20th century with the aim to provide quality pregnancy and birth care for underserved populations, such as rural Whites in southeastern Kentucky, rural women of Hispanic descent in Santa Fe, New Mexico, and Black and Puerto Rican women in New York City.[18] Most births attended by these midwives were at the childbearing person's home. In 1946, the Catholic Maternity Institute in Santa Fe, NM designated one of their freestanding buildings as a birth site, called La Casita.[18]

The Sheppard-Towner efforts largely focused on surveillance of perinatal health at the population level, which required the assimilation of – rather than cooperation with – the midwives who served as the primary birth workers.[68] Case in point, the nurses and educators employed by Sheppard-Towner funding increasingly saw established midwives as problematic to their efforts to standardize care, citing midwives' endorsement of tradition and superstition in particular.[52] This

conflict was dubbed “the midwife problem” by physicians and other public health stakeholders as early as 1913.[49] Public health practitioners and decision-makers sought to acknowledge midwives’ expertise but struggled to facilitate consensus between midwives and physicians regarding standardization of perinatal care.[52]

The state-mandated regulations regarding midwifery education and licensure that emerged from the US Children’s Bureau (established in 1912) failed to enfranchise established and experienced Black midwives. In 1950, 88% of births in the US occurred in a hospital with a physician.[18] Although their numbers were dwindling, Black midwives continued to practice without licensure in the face of legal penalties.[49] In the South, the Bureau’s integration of lay midwives was more intentional, resulting in the continued service of Black midwives until the 1960s,[68] compared to other parts of the country, where midwife-managed births declined due to permit denials and reduced demand.[52] The concurrent increase in the number of state-licensed clinics and hospitals considerably reduced rural people’s access to community birth and midwifery care.[49] Furthermore, the political disenfranchisement of midwives as experts in birth, as well as the perception of physician care as an economic privilege, increasingly encouraged middle class Black people to seek hospital births in the 1940s and 1950s.[19]

The characterizations of Black people as having poor health and being poorly educated supported the continued marginalization of both Black midwives and their Black childbearing clients well into the 20th century.[19,21] Experts and professionals falsely attributed the overall reduction in pregnancy-related mortality to the increased attention from a physician during pregnancy, referred to for the first time as prenatal care,[69] even though maternal mortality rates were reportedly higher among physicians compared to midwives.[18,49] Researchers later determined that these downward trends began before the widespread utilization of physician-led prenatal care

in the US and are largely attributable to antiseptic techniques during birth, which were already being applied by midwives.[69] Similarly, the beneficial health impacts of civil rights and Medicare/Medicaid legislation for Black people in the 1960s had waned by the 1980s, further reinforcing racial stereotypes in the medical field.[19,21]

With the growth of the women's movement in the 1970s, particularly among middle class White women, the US saw increasing calls for less medicalized approaches to childbirth and broader critiques of reduced bodily autonomy in medical care settings.[19] Consequently, state lawmakers developed policies that expanded licensing potential for the practicing midwifery community, which was and remains largely White, to legitimize their profession.[18,19] In 1975, the Maternity Center Association opened the Childbearing Center in New York City, representing the first in a new wave of out-of-hospital birthing sites, largely based on the structure of La Casita, operated by the Catholic Maternity Institute in Santa Fe until 1969.[18] Within 10 years of this center's opening, there were more than 80 birth centers in 35 states[70]; by 2010, this number doubled.[71] Currently, the American Association of Birth Centers (AABC) estimates that more than 384 of these facilities are serving childbearing people in 37 states.[72]

Throughout the 1980s and 1990s, many states required licensure for midwives and support from a licensed physician to practice, regardless of midwives' level of experience. This was especially challenging given the residual opposition to the midwifery model among physicians, as well as the resources needed for midwives to graduate from an educational program and pass qualifying exams.[19] Throughout the second half of the 20th century, legislation advanced to better support midwifery practice in the US, namely regarding national certifications: Certified Nurse Midwives (CNM), Certified Midwives (CM), and Certified Professional Midwives (CPM). Midwives with any of these three certifications can practice in the US, although licensure and

regulation differ by state. As Master's or doctoral level graduates of accredited nurse-midwifery education programs, CNMs can practice in all 50 states. The CM credential was introduced in 1994 as a way to integrate midwives with a background other than nursing.[18] While CMs also receive the same university-based education in midwifery, they are able to acquire licenses in only nine states as well as Washington, DC.[73] More than half of states allow for licensure of CPMs, although these direct-entry clinicians often face challenges in establishing collaborative agreements with physician practices.[38]

Suarez[19] posited that the professionalization of midwifery in the late 20th century without addressing issues of racial and reproductive justice prevented Black midwives from feeling involved in this movement. Instead, many Black birth workers have engaged in activist and collective work that focuses on these principles, including raising awareness about race-based inequities in perinatal health that continue to impact Black childbearing people today.[19]

1.3.2 Black childbearing people's engagement with community birth

Although rates of adverse perinatal outcomes are lower in birth centers for all racial groups when compared to national rates, research demonstrates that Black-White disparities persist in these settings. Among Medicaid beneficiaries using birth center services, Black clients experienced LBW at a rate of 5.9% (compared to 1.3% among Whites); PTB at a rate of 5.1% (4.2% among Whites); and a cesarean birth rate of 15.1% (10.6% among Whites).[8] It is important to note, however, that these studies of birth center care outcomes do not explicitly examine disparities by race. Rather, they provide descriptive findings by race, which limits the conclusions we can make about the source of these disparities. Furthermore, the evidence base includes only observational studies, as randomized controlled trial designs would require assigning participants

to receive different models of perinatal care, potentially conflicting with the principles of autonomy and beneficence in human subjects research.

The role of geography on access to and experience of birth center care remains unexplained. There are known state-level differences regarding how birth centers obtain licensing and accreditation,[38,39] but empirical investigation of how these contextual issues impact health outcomes among birth center clients is lacking. Licensure is provided to birth centers by the regulatory boards of their state, whose requirements vary. As of 2019, birth centers are not regulated at all in 10 states, subsequently preventing them from achieving facility licensure.[74] Birth centers may receive accreditation from the Commission for the Accreditation of Birth Centers,[75] which outlines standards that are specific to the care model, or the Joint Commission, which covers a broad range of healthcare facilities, including hospital and ambulatory care.[76] Generally, the purpose of birth center accreditation is to demonstrate the facility's adherence to established standards of care; it is often required by insurance payors for reimbursement.

Vedam, et al. applied a composite Midwifery Integration Scoring System (MISS) to assess the integration of midwifery services across the US.[38] In this study, the authors define integration as interprofessional collaboration and attribute reduced rates of maternal and neonatal deaths to this "seamless[38-3]" care provision. The investigators found the birthrate among Black childbearing people to be inversely correlated with midwifery integration scores; in other words, midwives tend to be more integrated in areas with fewer Black births.[38] While this study applied a piloted instrument and did not specifically examine the integration of birth center midwives, it provides further indication that Black birthing people have reduced access to services that are not hospital-based or physician-managed. There is limited published data specifically describing the barriers to birth center care unique to Black childbearing people.

The Family Health and Birth Center in Washington, DC and the Roots Community Birth Center in Minneapolis, MN have received coverage in academic journals regarding their model-based focus on building agency and community, specifically among their Black clients.[16,77] While these facilities can serve as exemplars, it is also important to research and understand the degree to which certain contextual elements (e.g., Medicaid credentialing) impact Black childbearing people's access to birth centers across the country.

Furthermore, as discussed previously, much of the research includes analytic samples at the onset of labor or at the time of birth, subsequently excluding Black birthing people who register for birth center care but do not remain with the practice. A recent study examining client-initiated transfer of care in a single birth center indicated that Black people were disproportionately represented in a sample of clients electing hospitalization during labor for non-medical reasons (i.e., personal choice). Racial disparities were not a focus of the study, but this spurious finding highlights a potential racial disparity in care experience for birth center clients.[78]

Other studies have addressed the specific elements of community birth that contribute to improved outcomes for childbearing people,[16,17,50,77] but there is minimal coverage in the literature on any differential impacts based on race or ethnicity. One recent study demonstrated the absence of any statistical difference in the reported quality of care received by Black and White birth center clients who completed longitudinal surveys during and after pregnancy.[5] However, these findings represent those of a piloted survey instrument that had not yet been validated for populations with different clinical and sociodemographic backgrounds.

1.4 SCIENTIFIC RESEARCH ON DISPARITIES IN PERINATAL HEALTH

Mainstream public health researchers and practitioners began to recognize health inequities rooted in social and contextual differences only in the 1970s and 1980s,[24,79] despite nearly a century of prolific writings from sociologists and behavioral scientists regarding racial and ecological disparities.[24,80] At the start of the 21st century, the US saw initiatives like Healthy People 2010, which included national calls for health equity, and increased recognition of SDOH as important factors related to morbidity and mortality disparities.[24] Concurrently, researchers were also acknowledging the health impact of stressors related to racism and other forms of discrimination for oppressed groups.[23,56,66,81-85]

1.4.1 Role of socioeconomic status

Socioeconomic disadvantage, typically assessed as fewer years of education and/or lower annual income, within the Black population in the United States is well studied with health impacts unique to Black childbearing people.[46,55,86] Examining infant mortality gaps between racial groups, researchers find consistent associations with individual-level factors of childbearing people, such as marital status, education, and age, which are also strongly related to income.[63] This is not to say, however, that increased income or education predict improved outcomes for this population. Recent research has demonstrated that increased socioeconomic status (SES) plays less of a protective role for Black birthing people compared to their White counterparts.[30,48,87] In a population-based sample from California, researchers found an increased risk of preeclampsia, a major contributor to PTB, among Black people when compared to the White subsample. The

investigators' analysis determined that higher SES reduced the risk of preeclampsia for White people, but not for Black people.[48]

This larger racial disparity found between socioeconomically advantaged childbearing people suggests other unmeasured factors related to the social experience, including stressors associated with exposure to racial and gendered discrimination.[30,31,46,47] Studies of foreign-born Black childbearing people demonstrate positive associations between time spent in the US and odds of adverse birth outcomes, such as PTB and LBW.[88-90] To explain this relationship, researchers point to the cumulative exposure to anti-Black racism in the US, in addition to other stressors related to acculturation and health care access, further illustrating the importance of context in studying perinatal health.[88] In addition, researchers have examined how the association between neighborhood-level circumstances and perinatal health outcomes differ by race.[27,28,65]

The concept of healthcare access encompasses insurance coverage. Researchers have repeatedly cited lack of insurance coverage, which is often linked to employment, as a major barrier for Black childbearing people to receive adequate and timely prenatal care.[34,54,55,91] Recent data from all sites of the Pregnancy Risk Assessment Monitoring System (PRAMS) estimated that 36% of pregnant people use Medicaid coverage for that time period.[92] For non-Hispanic Black and Hispanic populations, it is estimated that 65% and 59% of births, respectively, were financed by Medicaid, compared to 29% of births to non-Hispanic Whites.[93] In addition, factors like transportation access and affordability of childcare are closely associated with an individual's socioeconomic status, and researchers cite them as barriers to prenatal care for Black childbearing people.[34,55]

State-level policies regarding facility credentialing with insurance payors (e.g., Medicaid) are especially relevant to birth centers. Reportedly, 33 states have legislation permitting Medicaid

credentialing for birth centers, leaving many without this public insurance option that covers this model of care.[94] In addition, only 40 states and Washington, DC have licensing regulations for birth centers, making these types of facilities illegitimate in the remaining ten states, consequently reducing access for any pregnant people seeking that type of care in the remaining states.[72] While the passing of the Affordable Care Act in 2010 included the federal mandate that Medicaid programs reimburse for services at licensed birth centers,[95] the legislation failed to address states without licensing regulations, and its impact on payment for existing centers is unclear.

The average cost of birth center care (from early pregnancy to early postpartum) is about $7,300 without any insurance benefits,[96] compared to about $13,811 in US hospitals.[97] For many childbearing people, but especially those in lower socioeconomic strata (e.g., Medicaid beneficiaries), this is far from affordable without financial assistance. In its 2016 survey of existing birth centers, the American Association of Birth Centers reported that just 28 facilities (21%) hold contracts with Medicaid payors that reimburse for a bundled fee, which typically covers midwifery care throughout pregnancy and use of the facility for labor and birth. More centers report getting reimbursed by Medicaid payors for only the facility fee (48%), which covers labor and birth services (e.g., nursing care); or only the professional fee (69%), which covers midwifery care from pregnancy through postpartum. Many birth centers are currently experiencing financial hardships, due to limited decision-making power and a lack of policy support at federal and state levels.[96]

1.4.2 Relationships with care providers

Black childbearing people have cited the patient-provider relationship as an important factor regarding how they value prenatal care and trust their provider's recommendations.[53,55] In that vein, perceived mistreatment and cultural insensitivity have been consistently cited by this

population in literature addressing racial disparities in birth outcomes and Black individuals' preferences regarding prenatal care.[34,53,55,85,98] Black research participants describe care environments so potentially hostile, where racism and mistreatment are anticipated, that they delay initiation of prenatal care.[56,85] Similarly, Black participants in a qualitative study expressed that a lack of compassion or respect on behalf of their care providers contributed to prenatal care being a stressful and isolating experience, which in turn impacts the pregnant person's continued care engagement.[34]

In a recent study examining multiple birthing environments (e.g., hospital, birth center, home), Black childbearing individuals were more likely overall to report being mistreated or anticipate being mistreated by their care providers compared to Whites. The investigators cited lower reported mistreatment overall in birth centers, but these data were not stratified by race.[57]

This disparity in care experience is also reflected in other literature.[53-56,84] In addition to addressing patients' reported experiences of mistreatment in medical settings, perinatal clinicians describe a persistent "hidden curriculum" in clinical education and practice, where White colleagues remain silent even as they witness racialized mistreatment or other discriminatory behavior in healthcare settings.[84] While there is some literature exploring racial disparities in the midwifery workforce,[13,99] there is minimal insight into how this curriculum may play out in community birth settings.

Weisband, et al. demonstrated how these disparities in care may also persist in midwife-managed practices.[100] Black clients in this study were statistically more likely to transfer out of midwifery care, favoring physician-led care, even after controlling for medical indications of transfer. The authors discuss implicit racial biases that can affect the way majority White prenatal

care providers approach or interact with Black patients, consequently degrading the patient's trust in or perceived closeness with their provider.[100]

Increased diversity among perinatal care providers in the US, and in American healthcare in general, is thought to be essential for reducing disparities and would reflect an increasingly diverse patient population.[33,91,99] In a recent article, Karbeah, et al. described how racial concordance with providers enhances the care experience for birth center clients via trusting relationships.[17] The authors describe a shared motivation among birth workers of color to not only establish trusting relationships with clients but also to acknowledge the health impacts of historic inequity and racism in their daily lives.[17] Another study suggests that improved provider communication, as an overall strategy, is more important for childbearing people than racial concordance with their providers.[53] Current estimates indicate that about 10% of CNMs and 4% of obstetricians identify as Black or African American, even though this racial group makes up approximately 15% of the national childbearing population.[16] Given the scant literature[11,16,50] exploring Black childbearing people's perceptions of and engagement with birth centers, or community birth in general, there is not a comprehensive understanding of how the quality of patient-provider relationships relate to racially disparate care access and health outcomes in these settings.

1.4.3 Emerging study of structural racism and perinatal health

Over the last decade, a body of evidence demonstrating associations between structural racism measures and perinatal health at the population level (e.g., infant mortality rate) has emerged. Generally, the applicational premise of these measures is to quantify the impact of complex, intersecting systems that are rooted in a history of racial oppression and, theoretically,

contribute to the persistent racial inequities in health observed today. The literature cited here largely focuses on inequities between Black and White populations.

Examining racial inequities in SES at different geographic levels has revealed associations with overall rates of adverse birth outcomes, rates specific to Black childbearing people, as well as Black-White disparities in outcomes. The socioeconomic disparity measures typically used, and described here, include the Black-White ratio of adults 25 years or older with a bachelor's degree (i.e., educational attainment), the Black-White ratio of people 16 years or older with current employment, and the Black-White ratio of median household income. Two recent studies demonstrated reductions in overall rates of LBW and PTB, associated with increases in annual income and reduced income disparities.[101,102] Using medical records data, another study demonstrated how racial disparities in educational attainment and employment were associated with small-for-gestational-age births at the population level.[103] Specific to Black populations, evidence shows an association between socioeconomic disparities and the Black infant mortality rate (IMR).[104-106] In one study, greater racial disparity in educational attainment at the county level was not only associated with higher Black IMR but also lower White IMR.[104]

While research on residential segregation in relation to population health is not new, recent investigations have specifically examined the association between Black-White segregation and birth outcomes, including the racial disparities therein. Mehra, et al. published findings from a meta-analysis that showed higher risk of PTB for Black people living in racially segregated areas, compared to their White counterparts.[107] Another study using a national dataset indicated that racial segregation was significantly associated with Black-White disparities in stillbirths at the ZIP code level.[108] Two recent studies applying the Index of Concentration at the Extremes, a measure that assesses the degree to which a dominant (e.g., White) and oppressed (e.g., Black) group are

segregated within a geographical area, showed associations between index values and risk of neonatal or infant mortality.[109,110] Related to racial segregation, multiple studies have also identified redlining – or the historically racist practice of devaluing homes in predominantly Black neighborhoods – as a factor that continues to influence rates of adverse birth outcomes.[27,111-113]

The health impacts of discriminatory policing and mass incarceration are receiving increased attention in public health research overall,[114,115] and investigation of perinatal health disparities specifically. Using a linked dataset of birth certificates to describe infant mortality rates at the county level, Vilda, et al. demonstrated the Black-White ratio in prisoner populations was related to increased IMR in Black populations and decreased IMR in White populations.[116] Building on previous research around policing and associated stress, Hardeman, et al. used medical records data to demonstrate the relationship between high police contact and increased risk of PTB for Black and White populations, although Black people were more likely to live in areas with higher police contact.[117]

By quantifying the levels of structural racism to which childbearing populations are exposed, this research helps to contextualize the persistent racial inequities in perinatal health, observed over decades. In addition, the evidence highlights potential avenues for systems- or policy-level interventions that reduce levels of structural racism, and the race-based disparities, theoretically.

1.5 GOALS OF DISSERTATION

Black childbearing people represent a segment of the US population that is most vulnerable to adverse perinatal outcomes.[1,42-44] Given that birth centers have a demonstrated protective role

against adverse birth outcomes, such as PTB or low-risk cesarean birth,[6,8,118] it is paramount that clinicians, researchers, and policymakers alike understand how to maximize the application of this care model to reach the most vulnerable segments of the population.

As described, birth center midwives produce better health outcomes for all racial groups compared to conventional care in a hospital or maternity care home.[6-8,118] The potential to scale up access to this care model is largely hampered by a lack of funding and institutional support when practices reach the licensing and credentialing phases.[39] Researchers and practitioners acknowledge that the number of birth centers in the US definitively does not meet the demand for these services.[39] Given that Black people are under-represented among birth center clientele,[6,8,118] it also serves to point out that access is particularly diminished for this population, which experiences the highest risk of adverse birth outcomes compared to other racial groups.[20,30,81,86,119] Even so, there is limited literature contributing to our understanding of the level of access or awareness that Black people have regarding birth centers, let alone why they are under-represented in these settings.

In accordance with PHCRP, which conceptualizes racial and ethnic identity as a place- and time-specific social construct, [41] this research seeks to contextualize the issue of Black childbearing people's access to birth center services in the history of legal racial discrimination and racially disparate perinatal outcomes. Without considering this context, we are at risk of repeating the patterns of White providers dominating the midwifery field, thus reducing the chance of racial concordance for any patients who are not White; and implemention of care models associated with improved outcomes being made more available to White childbearing people. Furthermore, PHCRP can be used to interrogate and understand existing birth center and midwifery models,

acknowledging the intersectional identities and needs of the childbearing person, as well as the importance of context in providing prenatal and birth care.

By applying analytic methods that take time and space into account and centering Black childbearing people in study objectives and analyses, this dissertation work is expected to respond to the call for nuanced approaches in studying these disparities, specifically regarding access to birth center care.

1.6 SPECIFIC AIMS

The overall objectives of this dissertation research are to better understand the role of geographic proximity in Black childbearing people's access to birth center care and to identify actionable opportunities to expand access via structural and policy changes. The specific aims and hypotheses of each paper within this document are detailed below.

Paper 1:

Specific aim 1: Describe spatial clustering of birth center locations in the contiguous US from 2015 to 2019.

Hypothesis: It is predicted that there will be significant spatial autocorrelation of birth center locations at the county level, as well as the clustering of centers with current accreditation or licensure.

Paper 2:

Specific aim 2: Determine associations measures of structural racism (e.g., income inequality) and location of birth centers, adjusting for midwifery regulations (e.g., prescriptive authority) and demographics (e.g., urbanity).

Hypothesis: It is predicted that measures of structural racism at the county level will be associated with higher adjusted odds of birth center presence.

Paper 3:

Specific aim 3: Define and describe the demographic characteristics of service catchment areas for existing birth center locations in the contiguous US from 2015 to 2019.

Hypothesis: Census tracts in birth center catchment areas will have significantly larger proportions of childbearing populations with racial (e.g., non-Hispanic White) or socioeconomic privilege (e.g., living above the poverty level).

2.0 EXPLORING THE SPATIAL CLUSTERING OF BIRTH CENTER LOCATIONS IN THE CONTIGUOUS UNITED STATES

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2.1 ABSTRACT

Background: Giving birth at home or in a community setting, attended by a midwife or other experienced person, was the norm for childbearing people in the US until the late 19th century, when the professionalization of obstetrics set in motion the systematic disenfranchisement of midwives. In the 1970s, the US saw a resurgence of public interest in alternative birth sites, catalyzing the proliferation of freestanding birth centers, largely managed by midwives, throughout the country. Today, birth center care is associated with improved perinatal health outcomes for all racial and socioeconomic groups. However, population-level access to birth center care is understudied, even considering demographic disparities in clientele. The present study aims to examine spatial clustering of existing birth centers in the contiguous US between 2015-2019, including facility attributes like accreditation and licensure.

Methods: Using secondary data from the American Association of Birth Centers, this study applies tests of spatial autocorrelation to states and counties with at least one birth center in the contiguous US to explore how space influences the geographical distribution of these facilities.

Results: In examining states with birth centers, no significant spatial clustering was found. Spatial autocorrelation of counties with birth centers was positive and statistically significant ($p<0.05$), as were analyses by facility attribute (e.g., accreditation).

Discussion: Birth center locations in the US appear to cluster in Pacific states (e.g., California) and around metropolitan areas. Lack of clustering was indicated for states with birth centers, implicating more localized factors (e.g., networking and resource-sharing) as drivers for birth center locations.

2.2 INTRODUCTION

Over the last 40 years, research has demonstrated that birth center care in the US is associated with better outcomes for childbearing people with low-risk pregnancies of all socioeconomic and racial groups.[6-9] Providing home-like birthing environments distinct from tertiary care units (e.g., hospitals, NICUs),[120] most birth centers are freestanding and managed by professional midwives who apply a wellness- and person-centered care model that encourages and emphasizes the client's participation in health decision-making.[5-7] Landmark national studies of birth center care have demonstrated lower rates of low birthweight infants (LBW: < 2,500 grams at birth), preterm birth (PTB: birth at < 37 weeks' gestation), and cesarean birth, when compared to matched cohorts receiving conventional, hospital-based care.[6,9,10] It is estimated that 85% of pregnancies are medically low-risk and likely eligible for birth center care,[6] making it a public health research imperative to understand population-level access to this beneficial model.

History and geography continue to shape birth practices in the US, including where people choose to give birth. Before there were birth centers, there was community birth. Preceding the professionalization of obstetrics and midwifery, community birth consisted of experienced members of the community, often including family, being present to support and accompany childbearing people throughout labor in a home or other community setting. Contemporarily, community birth typically refers to giving birth in a home or birth center with a midwife. Community birth was the norm for childbearing people in the US from before the nation's inception until the late 19th century, with Black and African midwives being the primary caretakers for nearly all birthing people in the South.[19,49] In the post-Civil War context when racial segregation and anti-Black discrimination persisted in American public life, Black midwives were perceived by the White ruling class as uneducated and superstitious.[19,49] As medicine grew as a

professional field, and physicians – largely White and male – emerged as medical authorities, endorsement of midwives, and particularly Black midwives, declined. Even so, many "grand midwives" continued their practice in the south, well into the 20th century.[19,49,68]

After the passing of the Sheppard-Towner law in 1921, which facilitated major changes regarding medical education of practitioners, including midwives, the US saw collaborative midwife practices emerge in the first half of the 20th century. These practices not only trained midwives according to the newly established standards, but they also supervised care provision and maintained detailed documentation. The aim of this structure was to provide standardized, quality pregnancy and birth care for underserved populations, such as rural Whites in southeastern Kentucky, rural women of Hispanic descent in Santa Fe, New Mexico, and Black and Puerto Rican women in New York City. Most births attended by these midwives took place in someone's home. In 1946, the Catholic Maternity Institute in Santa Fe designated one of their freestanding buildings as a birth site, called La Casita.[18]

Dubbed "the midwife problem" in the early 20th century, public health physicians and nurses struggled to establish consensus with practicing midwives, faulting the latter's endorsement of tradition and superstition in their care approach. Once state-mandated regulations were put in place, midwives in many parts of the US were denied permits to practice, and demand for midwifery care declined considerably in the first half of the 20th century.[52] Concurrently, the number of state-licensed clinics and hospitals increased.[49] By 1950, 88% of births in the US occurred in a hospital with a physician[18]; more than 98% of births occur in hospitals today.[71]

In 1975, the Maternity Center Association (MCA) opened the Childbearing Center in New York City, representing the first in a new wave of out-of-hospital birthing sites.[18] Within 10 years of this opening, there were more than 80 birth centers in 35 states[70]; by 2010, this number

doubled.[71] The Cooperative Birth Center Network (CBCN) was founded by the MCA in 1981 to spur research on birth center care and to further promote the model; the CBCN rebranded as the American Association of Birth Centers (AABC) just two years later. In 2020, the AABC reported more than 384 existing birth centers in 37 states, representing a growth of 97% since 2010, or approximately 194 newly established birth centers in 10 years.[72]

There are state-level differences regarding how birth centers obtain licensing and accreditation,[38,39] but it is unclear to what degree this has impacted geographic distribution of these facilities. Passed in 2010, the Affordable Care Act required that Medicaid payors reimburse for services at licensed birth centers.[95] However, some states do not have licensing regulations for these facilities, thus eliminating Medicaid reimbursement and greatly reducing reimbursement from other insurance payors for centers in those states, despite the change in federal legislation.[94] This effectively reduces the accessibility of birth center care for childbearing people with Medicaid insurance in these states.

In a similar vein, state-level policy variation may limit the practice autonomy of midwives; these limitations are often tiered according to the midwife's clinical education and qualifications.[40] Three national certifications of midwifery are provided in the US: Certified Midwife (CM), Certified Nurse Midwife (CNM), and Certified Professional Midwife (CPM). All three certifications facilitate midwifery practice in the US, although licensure and regulation differ by state. As Master's or doctoral level graduates of accredited nurse-midwifery education programs, CNMs can practice in all 50 states. The CM credential was introduced in 1994 as a way to integrate midwives with a background other than nursing.[18] While CMs also receive the same university-based education in midwifery, they are able to acquire licenses in only nine states as well as Washington, DC.[73] More than half of states allow for licensure of CPMs, although these direct-

entry clinicians often face challenges in establishing collaborative agreements with physician practices.[38]

Given the geographic variation in birth center and midwifery care regulations, as well as historical trajectories of the midwife profession that differ regionally, the present study applies exploratory spatial data analysis to describe spatial clustering of states and counties where birth centers are located in the contiguous US, as well as the clustering of states and counties with centers that were accredited, licensed, or opened after 2010. Although variation in birth center regulations and midwifery scope of care occurs at the state level, it was strategic to also examine the clustering of counties with birth centers to determine spatial variation at a more granular level. Statistically, spatial clustering is also known as spatial autocorrelation, which implicates space and time as factors that influence variation in a measure (e.g., birth center presence). Significant spatial autocorrelation indicates that the value of a measure is influenced by the values of geographic areas in proximity. It is predicted that there will be significant, positive spatial autocorrelation of states and counties with at least one birth center; this is based on preliminary work using an original dataset of birth center addresses.[121]

2.3 METHODS

2.3.1 Study Design and Setting

This study applied spatial analyses to identify states and counties where birth centers are located in the contiguous US (48 states and Washington, DC; 3,108 counties) over a five-year period (2015-2019), including information on facility attributes (e.g., licensure status). This

protocol was approved as exempt from review by the Institutional Review Board in the Human Research Protection Office at the University of Pittsburgh.

2.3.2 Measures

The present study examined the spatial clustering of states and counties with the following counts: 1) birth centers; 2) accredited centers; 3) licensed centers; and 4) centers that opened after 2010, when the Affordable Care Act was passed, requiring that licensed birth center services be covered by state Medicaid payors.[95] Birth center presence at the state and county levels was determined using a dataset provided by the AABC after its Board of Directors approved the data use proposal in December 2021. This dataset included accreditation status, licensure status, mailing address, and opening year for birth centers that were open for all or some of the 2015-2019 period (N=479). The list was reduced by removing addresses outside the contiguous US (n=17), centers without street addresses (n=6), and duplicate addresses (n=11), leaving a final analytic sample of 445 birth centers.

Opening year was used to determine the longevity in years of each practice, as well as to identify those that opened after 2010. While the dataset provided response values for accreditation or licensure status that denoted rationale or intention (i.e., "seeking accreditation") for birth centers without these regulatory endorsements, these variables were recoded as binary (0=no accreditation/licensure; 1=accredited/licensed). Licensure is provided to birth centers by the regulatory boards of their state, whose requirements vary. Birth centers are not regulated at all in 10 states, subsequently preventing them from achieving facility licensure.[74] Birth centers may receive accreditation from the Commission for the Accreditation of Birth Centers,[75] which outlines standards that are specific to the care model, or the Joint Commission, which covers a broad range

of healthcare facilities, including hospital and ambulatory care.[76] Generally, the purpose of birth center accreditation is to demonstrate the facility's adherence to established standards of care; it is often required by insurance payors for service reimbursement.

First, the analytic sample of birth centers (N=445) was uploaded to QGIS (Version 3.10)[122] so that mailing addresses could be geocoded as point coordinates using the application's OpenStreetMap feature. Seventy addresses could not be geocoded this way, so an alternative approach was applied using the Geocode tool from Awesome[123] to produce latitude and longitude coordinates for each address via Google, which was merged with the point layer in QGIS. The "count points in polygon" feature in QGIS facilitated the generation of new variables representing the following counts at state and county levels: number of birth centers; number of birth centers with accreditation; number of birth centers with licensure; and number of birth centers that opened after 2010.

2.3.3 Spatial Analysis

This study used QGIS (Version 3.10) for geocoding, data management, and illustrative mapping of birth centers and county-level demographics. GeoDa (Version 1.20)[124] was also used to conduct global and local tests of spatial autocorrelation. Spatial adjacency was defined using a queen contiguity weights matrix in GeoDa. All shapefiles representing state and county boundaries were downloaded from the US Census Bureau website.

Univariate global Moran's I testing was conducted in GeoDa to assess spatial clustering of states and counties with at least one birth center. Global Moran's I testing consists of calculating the coefficient associated with spatial autocorrelation of the variable of interest, in this case, presence of a birth center. The value of the Moran's I statistic ranges from -1.0 to 1.0, where the

former indicates negative autocorrelation (perfect dispersion), and the latter indicates positive autocorrelation (perfect clustering). In the case that global testing produced a significant statistic in any analysis, univariate local Moran's I testing was conducted. Building on the global findings, local Moran's I testing identifies the locations of specific clusters. These include: 1) high-high clusters, representing areas where the presence of a birth center is associated with presence in a neighboring county; 2) low-low clusters, representing areas where the absence of a birth center is associated with absence in a neighboring county; 3) low-high clusters, representing areas where the absence of a birth center is associated with presence in a neighboring county; and 4) high-low spots, where the presence of a birth center is associated with absence in a neighboring county.

2.4 RESULTS

2.4.1 Birth centers

Table 1 provides details about the birth centers included for analyses (N=445). Missingness in the dataset occurred if birth centers did not provide information to the AABC, accounting for less than 10% of accreditation values, less than 20% of licensure values, and less than 3% of values for opening year. Most birth centers (n=271, 60.9%) in the contiguous US are licensed, but fewer than a third (n=124, 27.9%) are accredited. Nearly two thirds (n=276, 62.0%) of the birth centers operating between 2015-2019 report opening after 2010. Of these newer birth centers, 26.1% (72) of them reported being accredited and 59.1% (163) reported being licensed.

Table 1. Birth center sample (N=445) and facility-level attributes, including missingness of data.

Variable	n (%)	Missing n (%)
Accredited	124 (27.9)	43 (9.7)
Licensed	271 (60.9)	81 (18.2)
Open after 2010	276 (62.0)	11 (2.5)
Years open *Median (Interquartile range)*	8.0 (5.0-15.0)	11 (2.5)

Note: Percentages for variables and missingness are calculated using the N for the total analytic sample.

2.4.2 State and county attributes

Although birth centers exist in 41 states (83.7%), the presence of accredited (n=33, 67.4%) and licensed centers (n=37, 75.5%) is lower at the state level. Birth centers with both accreditation and licensure exist in just 29 states (59.2%). Nearly three quarters of states in the contiguous US (n=36, 73.5%) saw at least one birth center open after 2010. Most states (n=35, 71.4%) had fewer than eight birth centers during the 2015-2019 period. California, Florida, and Texas had the most of any state: 57, 43, and 109, respectively. These same states also saw the most birth centers open after 2010 of any other: 44, 19, and 67, respectively.

Birth centers exist in just 9% (n=272) of the counties in the contiguous US. Of the counties with at least one birth center, the average number of birth centers was 1.6. Los Angeles county had 10 birth centers, the most of any county in the contiguous US.

2.4.3 Mapping birth centers across the contiguous US

Figure 2 illustrates the locations of existing birth centers in the contiguous US from 2015-2019, as well as the 10 most populous cities. Maps illustrating the locations of accredited centers,

centers that opened after 2010, and licensed centers in the contiguous US are provided in the Appendix (Figures 5-7).

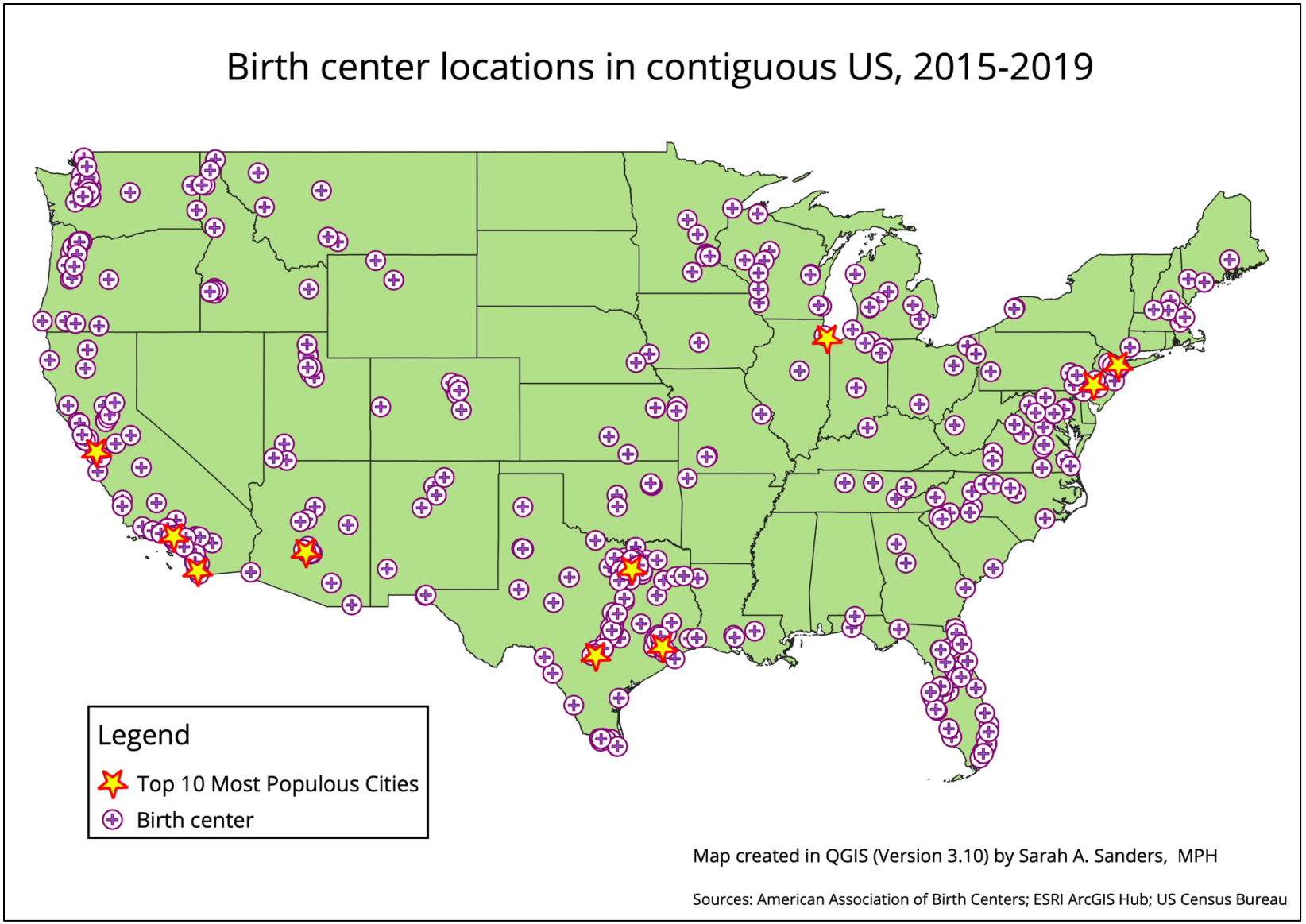

Figure 2. Map of existing birth centers (N=445) in the contiguous US, overlaid with the top 10 most populous cities.

2.4.4 Spatial autocorrelation

Table 2 shows the results of global Moran's I testing for states and counties with each of the four outcomes (e.g., at least one birth center). Global testing determined there to be significant spatial autocorrelation ($p<0.05$) of counties with each type of birth center, but not of states. In other words, counties with birth centers are more spatially clustered than would be expected at random.

Table 2. Statistics and significance values (based on 999 random permutations) for global Moran's I testing of states and counties with at least one birth center.

	Global Moran's I (p-value from 999 permutations)	
	States	**Counties**
All (N=445)	-0.01 (0.34)	0.26 (0.001)
Accredited (n=124)	0.08 (0.14)	0.13 (0.001)
Licensed (n=271)	-0.04 (0.43)	0.23 (0.001)
Opened after 2010 (n=276)	0.02 (0.21)	0.19 (0.001)

Based on the findings from global Moran's I testing, local testing was applied to counties with birth centers, but not states. Figure 3 shows that Local Moran's I testing of counties identified significant ($p<0.05$) birth center hot spots (high-high clusters: presence is associated with presence in a neighboring county) in multiple mountain states (e.g., Montana, Utah), northwestern states (e.g., Washington), southwestern states (including Texas), as well as in Florida, Massachusetts, and Wisconsin. There were no significant cold spots (low-low: absence is associated with absence in a neighboring county) identified for the presence of any birth center at the county level. Spatial outliers (low-high and high-low) appeared scattered across the country, with some concentration along national borders.

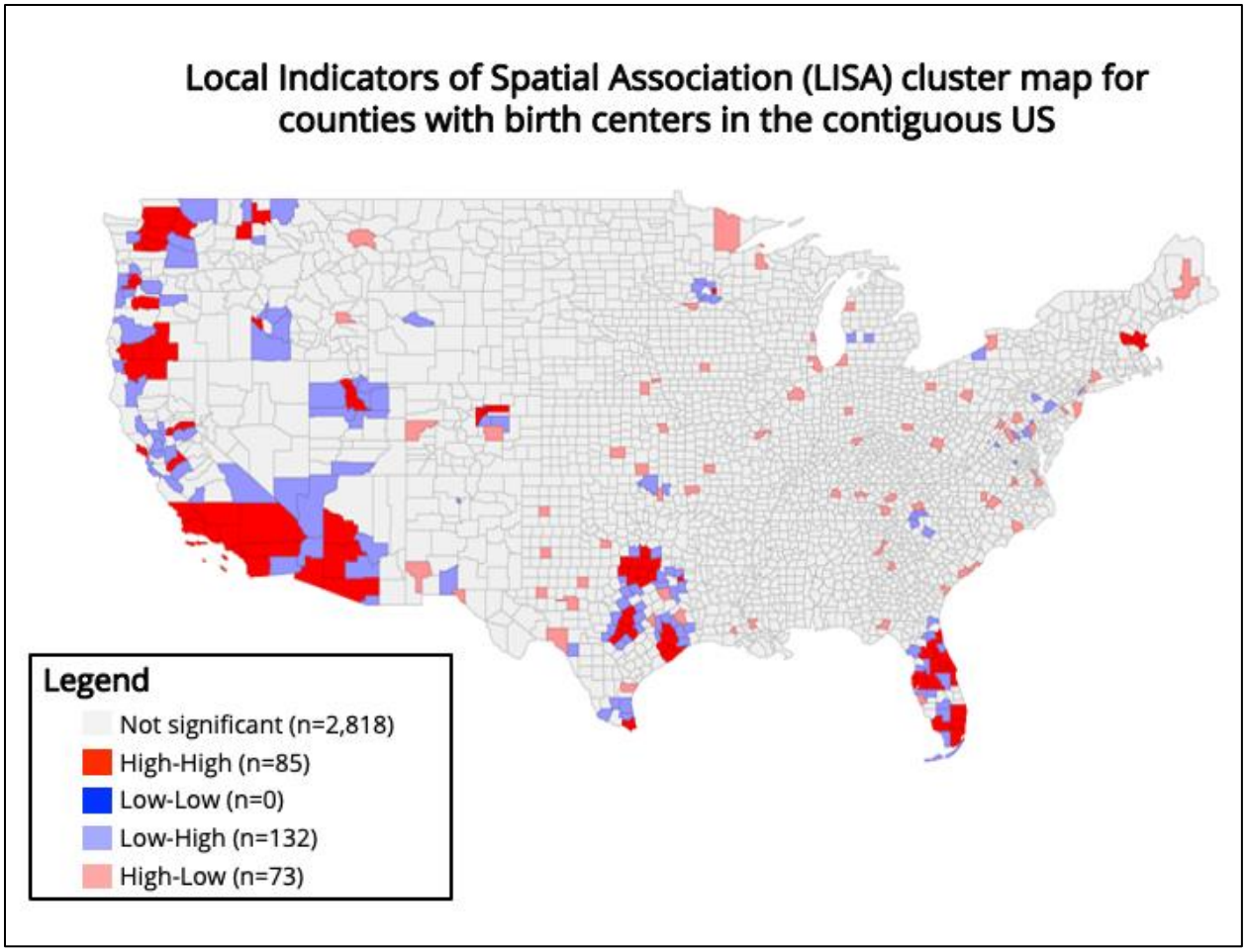

Figure 3. Cluster map of counties with at least one birth center, based on local Moran's I testing.

Significant hot spots for accredited birth centers were fewer, identified along the west coast, in Colorado (Denver area), in Texas (Houston area), and southeastern Pennsylvania. Cold spots appeared in the Pacific Northwest, Great Lakes region (Minnesota and Wisconsin), and along the mid-Atlantic coast. See the cluster map for accredited centers in the Appendix (Figure 9).

Licensed birth center hot spots were identified in the Pacific Northwest, southern California, Colorado (Denver area), Texas, Florida, and parts of the Northeast. Just four cold spots were identified on the east coast and in Wisconsin. See the cluster map for licensed centers in the Appendix (Figure 10). Compared to the cluster map for accredited centers, there were considerably

fewer low-high counties (n=137), indicating areas where licensed center absence was significantly associated with presence in a neighboring county.

Applying local Moran's I testing for counties with at least one birth center that opened after 2010 identified hot spots throughout mountain states (Colorado, Idaho, Utah), the Pacific Northwest, the Southwest (including Texas), Florida, Michigan, and Minnesota. Just two cold spots were identified for birth centers opening after 2010 in Massachusetts and Wisconsin. See this cluster map in the Appendix (Figure 11).

2.5 DISCUSSION

The present study demonstrated significant spatial autocorrelation of counties with at least one birth center during the 2015-2019 period, regardless of the attribute being examined (e.g., accreditation). In contrast, the hypothesis regarding significant clustering of states with birth centers was not supported by the present findings. Given that state-level policies around birth centers and midwifery care are not likely to be spatially related, the lack of clustering of states with birth centers seems reasonable. Birth centers appeared to cluster along the Western border and around the most populous cities. Notable gaps in birth center locations for this period appeared in the South (namely in Alabama, Arkansas, and Mississippi), northern Midwest, and Nevada.

Examining the clustering of birth centers that opened after 2010 was strategic; the passing of the Affordable Care Act (ACA) that year included a federal mandate that Medicaid reimbursement be available for all licensed birth centers.[95] However, 10 states still do not regulate birth centers and do not offer licensure. As illustrated in the map (Figure A2), nearly 300 birth centers opened all over the country between 2011-2019, even in states without licensing

regulations, like Idaho, Louisiana, and Michigan. Furthermore, Global Moran's I testing of states with centers that opened after 2010 did not indicate significant clustering. Together, these analyses suggest that the ACA mandate coincided with a national trend toward expanded birth center access, rather than bolstering support only in states with birth center regulations. Due to the cross-sectional nature of this study, however, it is not appropriate to directly attribute this growth to legislative changes. Future research should examine state-specific circumstances regarding birth center and midwifery regulations to better understand how the ACA impacted the growth of the birth center model in the US.

Significant spatial clustering of counties with birth centers, particularly those with accreditation and/or licensure, may indicate higher levels of networking and resource-sharing among birth centers in those areas. The mission of the AABC is to support birth centers and their staff through educational initiatives, fellowship, and policy work.[72] The AABC provides additional benefits for facility and individual members. While the present study did not examine AABC membership, future research should consider how this professional support facilitates expansion of the birth center model.

Save for reports and data analysis from the AABC, the birth center workforce is largely understudied in health literature, leaving minimal insight into how it impacts the establishment of new birth centers or the sustainability of existing ones. A recent survey of birth centers across the US indicated considerable variation in salaries for birth center midwives, especially when compared to midwife or nurse practitioner (NP) salaries in other settings. In nearly all states examined, the median annual income for birth center midwives was less than those reported for CNMs and NPs by the Bureau of Labor Statistics. The authors suggested that differences in pay for birth center midwives were related to reduced reimbursement for services from insurance

payors, serving as a major inhibitor of financial health for birth centers.[125] The present findings highlight the need to study local variation in midwife salaries by setting, as regional trends may help to explain the significant clustering of counties with birth centers indicated here.

Regarding birth center accreditation, an estimated 57% of facility respondents to the 2017 AABC Birth Center Survey reported being accredited. Based on the findings here, indicating fewer than a third of centers with accreditation, it seems that accredited centers were more likely to respond to the survey. In the same survey, about 34% of birth centers without accreditation cited the cost of achieving and maintaining accreditation as their reason for not seeking it; just 5% reported not agreeing with standards set by accrediting bodies.[96] In many states, accreditation facilitates licensure and/or reimbursement from insurance payors (including Medicaid), potentially expanding access to more childbearing people. There is minimal scientific insight regarding the clinical value of birth center accreditation, however, making this an area to explore in future research.

Another reason for the spatial clustering of counties with birth centers may be higher demand in those areas. Evidence describing geographical variation in preference for community birth is non-existent in scientific literature, however. Recent survey data imply a growing interest in community birth with midwives,[126] particularly in light of the COVID-19 pandemic.[127] Using population density as a proxy for demand in a post-hoc analysis, Figure 4 helps to illustrate how birth center locations overlap with counties designated as large metropolitans (population greater than one million), which are colored in dark green. In some cases, increased birth center presence completely obscures large these dark green metropolitan areas, as in the region around Dallas, Texas. More evidence is needed to better describe population-level demand for birth center care and how it relates to advancement of the birth center model.

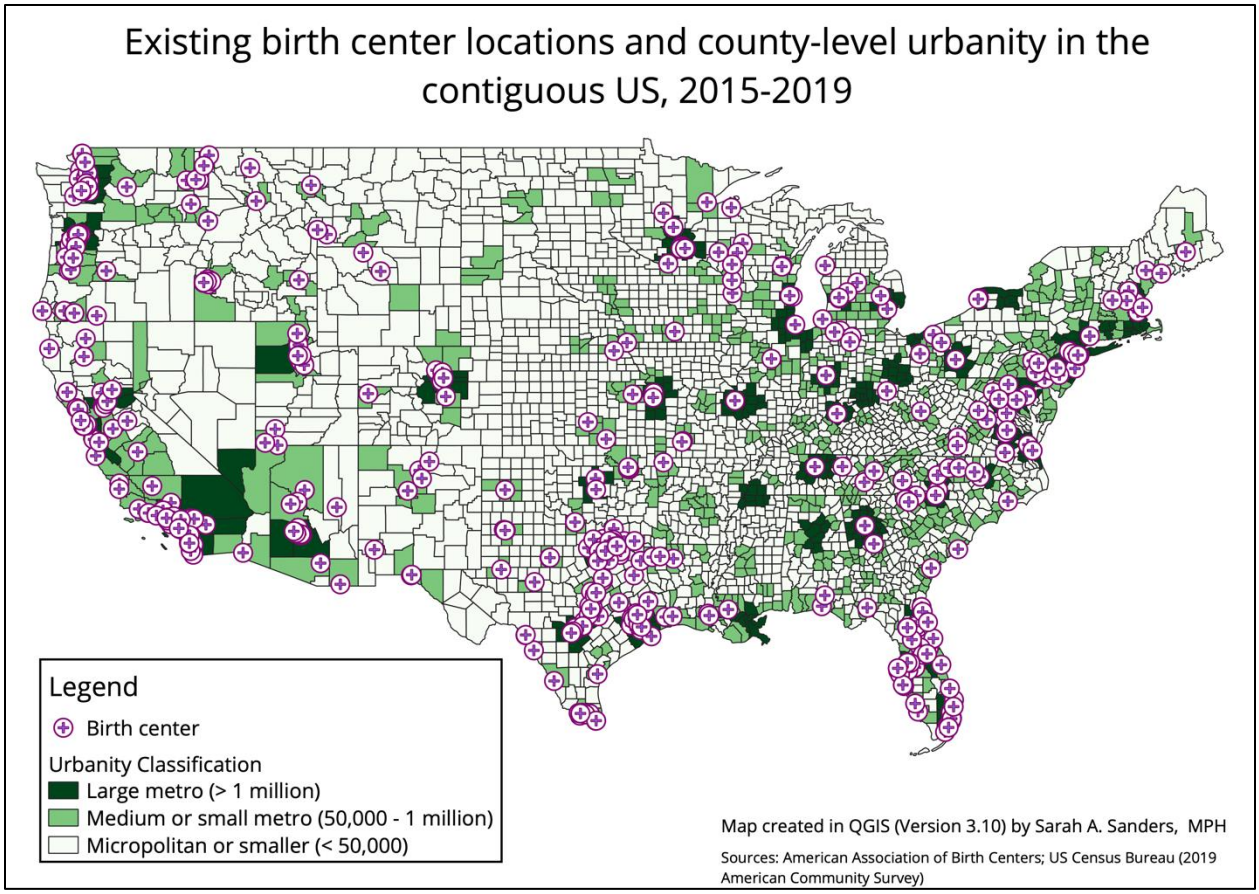

Figure 4. Map of birth center locations (N=445) and county-level population density in the contiguous US.

While the present study has contributed valuable knowledge of how birth centers are geographically distributed in the contiguous US, it is not without limitations. The analytic sample of birth centers and related attributes was sourced from a single organization. While comprehensive, it is possible that the list did not include all existing facilities or their regulatory statuses. To be clear, the AABC included birth centers in their dataset even if the facility was not an organizational affiliate. Even so, independently surveying birth centers about their licensure and accreditation, as well as other facility attributes, may yield different results regarding spatial clustering of these facilities and the factors influencing expansion of the birth center model. In this

vein, missingness was a present, albeit minor, issue for variables representing accreditation, licensure, and longevity of the practice.

2.5.1 Implications

The present findings suggest severe gaps in access to birth center care for many parts of the country, particularly rural areas in the northern Midwest and the South. The analytic sample of birth centers examined here did not include addresses for any facilities in the following six states: Alabama, Mississippi, Nevada, North Dakota, South Dakota, and Vermont. These states mainly consist of counties with low population density (Figure 4). The regulatory bodies for Alabama, North Dakota, and Vermont do not regulate birth centers, which eliminates the possibility of facility licensure in those states, and thus federally mandated reimbursement from Medicaid payors. There are seven other states (e.g., Idaho) without birth center regulations,[94] each of which has at least one center, potentially implicating other systemic barriers in states without birth centers.

The spatial clustering of birth centers demonstrated here echoes the particularly harsh consequences of obstetric professionalism faced by practicing midwives in the early 20th century. Concurrent increases in the number of state-licensed clinics and hospitals considerably reduced rural people's access to community birth and midwifery care during this time.[49] Furthermore, the obvious gap in birth center access for childbearing people living in southern states, regardless of state-level regulations, seems contradictory to the region's historical legacy of midwifery.[19] Granted, midwives that practiced in the South through the early 20th century, largely Black and descendants of enslaved people, were targeted by the predominantly White and male medical

profession in the latter's efforts to discredit any care approach that did not align with their standards of obstetrical care.[19,49]

It is also relevant to highlight that the highest rates of infant and maternal mortality in the country are reported in southern states. Recent data from the CDC showed infant and maternal mortality rates more than twice that of the national average in states like Alabama, Arkansas, Louisiana, and Mississippi.[128,129] Within strategies to proliferate the birth center model and expand access to this care, it is imperative to consider how systemic racism and suppression of midwifery care inhibit growth, particularly in relation to access for oppressed childbearing populations that could most benefit from birth center care.

3.0 SYSTEMS-LEVEL FACTORS RELATED TO BIRTH CENTER LOCATIONS IN THE CONTIGUOUS US: AN APPLICATION OF STRUCTURAL RACISM MEASURES

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3.1 ABSTRACT

Background: Literature illustrates how racism has shaped the trajectories of midwifery care and the health of Black childbearing populations in the US. Despite the historical legacy of Black midwives, particularly in the South, the current midwifery workforce and birth center clientele remain largely white. Applying Public Health Critical Race Praxis, this study aims to assess the relationship between measures of structural racism and birth center presence at the county level.

Methods: Using secondary data from multiple sources, including the US Census Bureau, this study applies multivariable logistic regression to describe county-level associations between measures of structural racism (e.g., employment inequity, residential segregation) and birth center presence, controlling for factors related to midwifery scope of care (e.g., prescriptive authority) and demographic characteristics (e.g., childbearing population proportion living in poverty, population size).

Results: Increased levels of structural racism, represented by racial inequity in employment and racial segregation, were positively associated with birth center presence at the county level, even after adjusting for midwifery scope of care and population size. In contrast, racial inequity in employment at the county level was inversely associated with birth center presence in multivariable regression models after adjusting for midwifery scope and population size.

Discussion: This study provides data on the relationship between structural racism and presence of birth centers in counties across the US. This work informs future research and policy, focused on the influences of structural inequity and expanding access to the birth center care model.

3.2 INTRODUCTION

Community birth was the norm for childbearing people until the late 19th century, with Black and African midwives being the primary caretakers for many birthing people, especially in the South.[19,49] Historically, community birth consisted of the childbearing person being accompanied and assisted during labor by experienced community members in a home. Today, community birth typically means giving birth at home or in a birth center with a midwife, often with other support as well (e.g., partner, doula). Most birth centers in the United States (US) are freestanding, managed by professional midwives who apply a wellness- and person-centered care model that encourages and emphasizes the client's participation in health decision-making.[5-7] This model of care has been consistently associated with better outcomes (e.g., lower rates of preterm birth) for childbearing people with low-risk pregnancies of all socioeconomic and racial groups compared to nationally representative statistics.[6-9]

The emergence of medicine as a professional field in the late 19th century elevated physicians – almost exclusively White and male, as the authorities of obstetrical care and perinatal health. Concurrently, midwives suffered decades of professional and community persecution that nearly eradicated public awareness of their centuries-long legacy of providing safe birth care in the US.[19,49] Black midwives were specifically targeted and disenfranchised, as the American public – and the field of medicine for that matter – continued to endorse racist characterizations of Black people as being poorly educated and having poor health.[19,21]

With the growth of the women's movement in the 1970s, particularly among middle class White women, the US saw increasing calls for less medicalized approaches to childbirth. Lawmakers responded by developing policies that facilitated licensure for practicing midwives, a group that was and remains largely White.[19] Currently, practicing midwives can receive Certified

Midwife (CM) or Certified Nurse Midwife (CNM) credentials from the American Midwifery Certification Board, or the Certified Professional Midwife (CPM) credential from the North American Registry of Midwives. Even though the credentialing process for CPMs includes clinical competencies that are similar to CNMs/CMs, university-based education is not a requirement for CPMs.[130]

In 1975, the Maternity Center Association opened the Childbearing Center in New York City, representing the first in a new wave of out-of-hospital birthing sites.[18] In 2020, the American Association of Birth Centers (AABC) reported more than 384 existing birth centers in 37 states, representing a growth of 97% since 2010, or approximately 194 newly established birth centers in 10 years.[72] Even so, an estimated 90% of the increase in out-of-hospital births (i.e., community births) between 2004-2010 was attributed to those among non-Hispanic White people.[71] About 15% of the childbearing population in the US report identifying as Black or African American, but national birth center studies indicate disproportionate representation of this population in their analytic samples.[6,8] Furthermore, even as the US population has become more racially and ethnically diverse over the last 20 years, the midwifery workforce has remained more than 90% White.[131]

The lack of insight in the literature regarding racially disparate engagement with birth center care, and community birth generally, is troublesome. Given the demonstrated benefits of birth center care, as well as the model's potential to reduce inequities in perinatal health, the issue deserves more attention.[6-8,11] Applying principles of Public Health Critical Race Praxis (PHCRP), this study seeks to better understand how historic racial inequities impact contemporary engagement with birth center care. PHCRP is rooted in legal frameworks, namely Critical Race Theory and Black Feminist Theory, and consists of four focuses of racial consciousness.[41]

In addition to framing racism, not race, as a pervasive factor impacting health at the population level, PHCRP urges the study of contextual factors that influence observed inequities.[41] The evidence available suggests a racial disparity in birth center engagement, but the drivers are unclear and understudied. In this vein, it is relevant to consider the segregated and exploitative history[20,21] of Black people in the American healthcare system, which includes medical mistreatment and abuse,[20] White supremacist violence,[20] and the rise of eugenic programs based on since-debunked research.[60-62] Additionally, the role of geography in determining population-level access to birth center care remains unexplained. Even so, there is known geographic variability in childbearing demographics, perinatal health, and birth center regulations,[35,38,39,45] further underscoring the application of the context-focused framework of PHCRP.

PHCRP also calls for the consideration of how knowledge is produced and disseminated in a society with racist foundations.[41] Mainstream public health researchers and practitioners did not begin to recognize health inequities rooted in social and contextual differences until the 1970s and 1980s,[24,79] despite nearly a century of prolific writings from sociologists and behavioral scientists.[24,80] For Black childbearing people in hospital-based perinatal care settings, recent literature cites continued mistreatment and provider mistrust as factors influencing access to care and subsequent outcomes.[23,56,66,81,85,88] Scientific study of these issues in the birth center context is practically non-existent, save for case studies that describe birth centers where the care philosophies are explicitly centered on the needs of Black childbearing people.[16,77,132] In researching birth center care and advancing the model, it is important to take into account the racialized history of health care provision for Black people, as well as how racism may pervade all birth settings and approaches to care.

Research around measures of structural racism and childbearing health at the population level is emerging and powerful. Rates of adverse perinatal outcomes for Black people, such as preterm birth (PTB) or infant mortality, are significantly associated with proxy measures of systemic racial inequity, including Black-White disparities in educational attainment,[103-105] employment,[103] incarceration,[116] income,[101] and racial segregation.[107,108] Applying PHCRP, the present study builds on this evidence base by examining growth of the birth center model in relation to the racially oppressive social conditions inherited by the present.[20] This study aims to describe the relationship between county-level measures of structural racism (e.g., income inequality) and existing birth center locations, controlling for demographics (e.g., population size) and midwifery scope of care (e.g., prescriptive authority). Given the racialized history of the obstetric profession, as well as the predominantly White and middle-class origins of the birth center movement, it is hypothesized that measures of structural racism (i.e., greater racial disparity or inequity) will be significantly associated with birth center presence at the county level in the contiguous US.

3.3 METHODS

3.3.1 Study Design and Setting

Using data from multiple sources, this study applied regression to estimate the relationships between measures of structural racism and birth center presence at the county level in the contiguous US (48 states and Washington, DC; 3,108 counties) over a five-year period (2015-

2019). This protocol was approved as exempt from review by the Institutional Review Board of the Human Research Protection Office at the University of Pittsburgh.

3.3.2 Measures

The present study examines the following three outcomes at the county level in the contiguous US: presence of at least one birth center; presence of at least one accredited center; and presence of at least one licensed center. State regulatory boards provide licensure to birth centers, and their requirements vary. In 10 states birth centers are not regulated at all, eliminating the option of facility licensure.[74] Birth center accreditation is provided by the Commission for the Accreditation of Birth Centers[75] or the Joint Commission, which accredits a wide range of healthcare facilities, including hospital and ambulatory care.[76] The general purpose of accreditation is for the birth center to demonstrate its adherence to certain standards of care; insurance payors may require accreditation for service reimbursement.

Outcome variables for birth center presence were derived from a list of birth centers (N=479) that were open for some or all of the 2015-2019 period, provided by the AABC after its board approved the data use proposal in December 2021. This list included the following data: mailing addresses, current licensure and accreditation status, and opening year of the practice, allowing for calculation of its longevity (in years). Addresses outside the contiguous US (n=17), centers without street addresses (n=6), and duplicate addresses (n=11) were removed. The final list of facility addresses (N=445) was then geocoded using the OpenStreetMap feature in QGIS (Version 3.12).[122] Awesome Table[123] was used as an alternative approach to geocoding 70 addresses that were not found using the first tool. Finally, the three binary variables indicating

birth center presence (x=1) at the county level were generated in QGIS and exported for statistical analysis.

The main exposure variables examined in this study are based on data from multiple, publicly available sources to describe structural racism at the county level in the contiguous US. Table 3 details the evidence-based measures used in the present study to illustrate structural racism, specifically disparities between Black and non-Hispanic White populations in the US. All measures sourced from the 2019 ACS were extracted as raw datasets and calculated with statistical software (Stata SE, Version 16.1).[133] Other measures were extracted from downloaded datasets containing aggregate data at the county level, not requiring calculation. Regarding rates of infant mortality (infant death before one year) and low birthweight births (infants weighing under 2,500 grams), values were censored for counties with fewer than 20 births.

Table 3. County-level measures illustrating structural racism, including their respective determinations and data sources.

Variable	Calculation/Determination	Years	Source
Educational attainment	Percent of Black population over 25 years with a Bachelor's degree or higher *divided by* percent of NHW population over 25 years with a Bachelor's degree or higher	2015-2019	2019 ACS, 5-year estimates (US Census Bureau)
Employment	Percent of Black population over 15 years with employment *divided by* percent of NHW population over 15 years with employment	2015-2019	2019 ACS, 5-year estimates (US Census Bureau)
Infant mortality rate	Infant deaths per 1,000 live Black births *divided by* infant deaths per 1,000 live NHW births	2013-2019	County Health Rankings
Incarceration	Percent of Black population in prison *divided by* percent of NHW population in prison	2015	2020 Incarceration Trends Dataset (Vera Institute of Justice)
Income	Median household income for Black population *divided by* median household income for NHW population	2015-2019	2019 ACS, 5-year estimates (US Census Bureau)
Low birthweight rate	Percent of Black births considered low weight (<2,500 grams) *divided by* percent of NHW births considered low weight	2013-2019	County Health Rankings
Index of dissimilarity	Evenness with which Black and NHW populations are distributed across census tracts within a county; values range from 0-100 (1=least segregated) $D = \frac{1}{2}\sum_{i=1}^{n}\left\lvert\frac{w_i}{W_T} - \frac{b_i}{B_T}\right\rvert$ n= number of census tracts in the county w^i= number of NHWs in census tract i W_T= total number of NHWs in the county b^i= number of Blacks in tract i B_T= total number of Blacks in the county	2013-2019	County Health Rankings
Index of concentration at the extremes	Social polarization within a county, quantifying extremes of deprived (Black) and privileged (NHW); values range from -1.0 to 1.0 (-1.0 corresponds to complete deprivation) $ICE_i = \frac{(A_i - P_i)}{T_i}$ A_i= number of NHWs in county P_i= number of Blacks in county T_i= total population in county	2015-2019	2019 ACS, 5-year estimates (US Census Bureau)

ACS: American Community Survey; NHW: non-Hispanic White

Preliminary analysis revealed non-linearity among every structural racism measure, so these continuous variables were recoded as indicator variables for each quartile, with the lowest quartile designated as the reference category. This was conducted in Stata by determining the five-

number summary of the variable distribution (minimum, first quartile, median, third quartile, and maximum). First quartile values for nearly all structural racism measures represented categories with the lowest levels of structural racism. The Index of Concentration at the Extremes, however, is a two-sided measure, ranging from -1.0 to 1.0, where negative values represent segregation that maximizes deprivation for the oppressed population (Black/African American populations); and the highest positive values (first quartile) represent segregation that maximizes privilege for the dominant population (non-Hispanic White).

Several covariates were included in the present regression analyses to account for regulation of midwifery scope of care and demographics at the county level, both of which were theorized to be related to birth center presence.. First, using publicly available data from the 2015 Midwifery Integration Scoring System (MISS),[38] this study incorporated information related to midwifery autonomy and scope of care, which varies by state and type of credential, detailed in Table 13 in the Appendix. Values for Alaska and Hawaii were removed from the extracted MISS data, maintaining those for the contiguous US, including Washington, DC (N=49). Several of the categorical variables were collapsed into fewer groups or as binary measures, which is detailed in Table 14 in the Appendix. In addition, the midwifery integration score was converted from a continuous to categorical variable, with each group representing a quartile of values. Quartile values for midwifery integration scores[38] were as follows: 1) 17-27; 2) 28-36; 3) 37-47; and 4) 48-61.

Several measures were pulled from the 2019 American Community Survey (ACS) as county-level demographic covariates, describing overall and childbearing populations (Table 4). Five-year estimates provided in the ACS fertility tables, describing females aged 15-50 years, were

used to calculate childbearing proportions. Urbanity classification data from the US Census were also attributed to each county.

Table 4. County-level variables representing overall and childbearing demographics, based on the five-year estimates from the 2019 American Community Survey.

Variable	Type	Definition & Values
Black population proportion	Continuous	Percentage of total population identifying as Black or African American
NHW population proportion	Continuous	Percentage of total population identifying as non-Hispanic White
Census division	Categorical	New England (1), Middle Atlantic (2), East North Central (3), West North Central (4), South Atlantic (5), East South Central (6), West South Central (7), Mountain (8), and Pacific (9)
Urbanity classification	Categorical	Large central metro (>1 million people); large fringe metro (>1 million people); medium metro (250,000-1 million people); small metro (50,000-250,000 people); micropolitan (MSA, <50,000 people); noncore (non-MSA)
Black childbearing population proportion	Continuous	Percentage of total childbearing population (females 15-50 years) identifying as Black or African American
NHW childbearing population	Continuous	Percentage of total childbearing population (females 15-50 years) identifying as non-Hispanic White
Non-native childbearing population	Continuous	Percentage of total childbearing population (females 15-50 years) born outside the United States
Childbearing population receiving public assistance	Continuous	Percentage of total childbearing population (females 15-50 years) that received public assistance benefits in the last 12 months
Childbearing population living in poverty	Continuous	Percentage of total childbearing population (females 15-50 years) that are earning an income equivalent to or less than 100% of the poverty level

3.3.3 Statistical Analysis

First, descriptive data were provided for included birth centers (N=445) and their attributes, as well as for exposure variables and covariates at the county level. Although descriptive data are provided for all three midwife credentials in the Results, only CPM measures were included in regression analyses due to their greater degree of variability at the state-level compared to those for CMs or CNMs. The expectation was that study findings would be more actionable since CPMs tend to be more restricted in their clinical autonomy compared to midwives with other credentials.

Applying logistic regression to a merged dataset that contained all county- and state-level information, univariable relationships were assessed between each exposure variable (measures of structural racism) and covariate (midwifery scope, demographics) and the three outcomes of interest.

Next, in preparation for multivariable analyses, a correlation matrix was generated to identify statistical associations between covariates. The Pearson correlation coefficient (*r*) was used to compare continuous variables (e.g., Black childbearing population proportion), while the Spearman coefficient (*p*) was used to compare a continuous variable with an ordinal one (e.g., urbanity classification). Tetrachoric and polychoric correlation (*r*) were used to calculate the correlations between binary variables (e.g., Medicaid reimbursement for CPMs) and ordinal variables, respectively. Correlating continuous and ordinal variables required applying the Kruskal-Wallis test (*H*). Lastly, correlating continuous and binary variables required calculating the point-biserial correlation coefficient (*r*). Covariates were removed if they demonstrated strong associations with others or based on investigator discretion. For this purpose, the thresholds for strong associations between covariates were values above 0.50 for tests of correlation and p-values below 0.05 for Kruskal-Wallis tests.

Applying a backward stepwise approach, the first logistic regression model for each outcome included all covariates retained after reviewing the correlation matrix. Then, covariates were retained if at least one factor had a significant odds ratio (OR) below the 0.05 alpha level; all others were removed before running the second regression model. This process continued until all covariates had at least one factor with a significant OR ($p<0.05$).

All activities related to data management, descriptive statistics, and regression analyses are conducted using Stata SE (Version 16.1).[133]

3.4 RESULTS

3.4.1 Birth centers

Table 5 provides details about birth centers included for analysis, as well as their attributes. Although more than half of birth centers (n=271, 61%) were licensed during the 2015-2019 period, less than a third (n=124, 28%) reported being accredited. The median value for practice longevity was estimated to be 8.0 years. Some values were missing because birth centers did not provide this information to the AABC; this accounts for less than 10% of accreditation values, less than 20% of licensure values, and less than 3% of values for opening year.

Table 5. Birth center sample (N=445) and facility-level attributes, including missingness of data.

Variable	n (%)	Missing n (%)
Accredited	124 (27.9)	43 (9.7)
Licensed	271 (60.9)	81 (18.2)
Years open *Median (Interquartile range)*	8.0 (5.0-15.0)	11 (2.5)

3.4.2 Structural Racism Exposures

Missingness was a considerable issue for several of the structural racism measures due to a combination of data censoring (small population estimates and birth outcomes) and state- or county-level withholding of information, as was the case with incarceration estimates. Table 6 details the distributions of the continuous measures analyzed as structural racism exposures, as well as the degree of missingness for each variable.

Table 6. Distribution of continuous measures of structural racism and percent of missingness for all counties in the contiguous US, including Washington, DC (N=3,108).

Variable	n (%)	Missing % (n)
B-NHW ratio for IMR[a]	85 (2.7)	2775 (89.3)
Quartile 1 (1.00-1.90)	85 (2.7)	
Quartile 2 (1.91-2.40)	82 (2.6)	
Quartile 3 (2.41-3.10)	82 (2.6)	
Quartile 4 (3.11-7.40)	84 (2.7)	
B-NHW ratio for LBW[b]	346 (11.1)	1722 (55.4)
Quartile 1 (0.70-1.60)	346 (11.1)	
Quartile 2 (1.61-1.80)	344 (11.1)	
Quartile 3 (1.81-2.10)	345 (11.1)	
Quartile 4 (2.11-4.50)	351 (11.3)	
B-NHW ratio for bachelor's or higher[c]	735 (23.7)	129 (4.2)
Quartile 1 (0.81-9.00)	744 (23.9)	
Quartile 2 (0.51-0.80)	764 (24.6)	
Quartile 3 (0.21-0.50)	736 (23.7)	
Quartile 4 (0.00-0.20)	735 (23.7)	
B-NHW ratio for employment rate[d]	740 (23.8)	99 (3.2)
Quartile 1 (1.01-2.90)	716 (23.0)	
Quartile 2 (0.91-1.00)	811 (26.1)	
Quartile 3 (0.71-0.90)	742 (23.9)	
Quartile 4 (0.00-0.70)	740 (23.8)	
B-NHW ratio for median household income[e]	452 (14.5)	1216 (39.1)
Quartile 1 (0.81-3.50)	406 (13.1)	
Quartile 2 (0.61-0.80)	638 (20.5)	
Quartile 3 (0.51-0.60)	433 (13.9)	
Quartile 4 (0.10-0.50)	415 (13.4)	
B-NHW ratio for prisoner population proportion[f]	372 (12.0)	1613 (51.9)
Quartile 1 (0.00-2.70)	372 (12.0)	
Quartile 2 (2.71-4.10)	374 (12.0)	
Quartile 3 (4.11-6.50)	375 (12.1)	
Quartile 4 (6.51-131.00)	373 (12.0)	
Index of dissimilarity (B-NHW)[g]	519 (16.7)	1030 (33.1)
Quartile 1 (1.10-33.90)	519 (16.7)	
Quartile 2 (33.91-45.40)	520 (16.7)	
Quartile 3 (45.41-56.70)	519 (16.7)	
Quartile 4 (56.71-93.50)	520 (16.7)	
Index of concentration at the extremes (B-NHW)[h]	769 (24.7)	0 (0.0)
Quartile 1 (0.91-1.00)	793 (25.5)	
Quartile 2 (0.81-0.90)	755 (24.3)	
Quartile 3 (0.51-0.80)	791 (25.5)	
Quartile 4 (-0.80-0.50)	769 (24.7)	

[a]Infant mortality ratio is calculated for each county by dividing the Black infant mortality rate (infant deaths per 1,000 live births) by the non-Hispanic White infant mortality rate

[b]Low birthweight ratio is calculated for each county by dividing the Black low birthweight rate (percent of infants born below 2,500 grams) by the non-Hispanic White low birthweight rate

[c]Educational attainment ratio is calculated for each county by dividing the proportion of Black people over 25 years old with a bachelor's degree by the proportion of non-Hispanic White people over 25 with a bachelor's

[d]Employment ratio is calculated for each county by dividing the proportion of Black people over 16 years old with employment by the proportion of non-Hispanic White people over 16 with employment

[e]Income ratio is calculated for each county by dividing the median income for the Black populations by that for the non-Hispanic White populations
[f]Prisoner population ratio is calculated for each county by dividing the Black prisoner population proportion by the non-Hispanic White prisoner population proportion
[g]Index of Dissimilarity values are determined for each county by calculating the difference between the relative distribution of Black and non-Hispanic White population proportions across census tracts within that county
[h]Values for the Index of Concentration at the Extremes are determined for each county by summing the absolute differences between Black and non-Hispanic White population proportions, dividing census tract totals by county totals, and multiplying this sum by 0.5.
B-NHW: Black to non-Hispanic White; IMR: infant mortality rate; IQR: interquartile range

Although many of the values are missing for the race-based ratios of infant mortality (IMR) and low birthweight births (LBW), Black childbearing people seem to bear a disproportionate burden of these adverse outcomes at the county level. Median values for IMR and LBW ratios are 2.4 and 1.8, respectively. Similarly, the median values for ratios describing racial differences in educational attainment, employment, and annual income were all below 1.0. This indicates that, proportionally, Black people are less educated, underemployed, and earning lower incomes in at least half of the counties in the contiguous US, compared to their non-Hispanic White counterparts. The ratio comparing Black and non-Hispanic White prison populations did not fall below 1.0 in any county and reached over 56.0 in about a quarter of the counties analyzed.

The two indices provided in Table 6 describe residential segregation of Black and non-Hispanic White populations. Values for the Index of Dissimilarity range from 0-100, with increasing values representing increased levels of racial segregation. In the present study, this variable ranged from 1.1 to 93.5, with a median value of 45.4, indicating considerable county-level variation across the country. The Index of Concentration at the Extremes consists of values between -1.0 and 1.0, representing a spectrum from complete deprivation (-1.0) for the oppressed population to complete privilege (1.0) for the dominant population. Although county-level values for this index ranged from -0.8 to 1.0, the median value of 0.8 indicates that most counties in the contiguous US are segregated in a way that privileges non-Hispanic White over Black populations.

3.4.3 Covariates for midwifery scope and childbearing demographics

Table 7 provides descriptive information about midwifery scope and autonomy for states in the contiguous US, including Washington, DC (N=49). It is important to note that for several variables, descriptive data are provided for only states where licensure is available for midwives with the credential indicated. There were no missing values for any variable.

Table 7. Descriptive data regarding midwifery scope of care for counties in the contiguous US (N=3,108).

	n (%)		
	CM	**CNM**	**CPM**
State regulation			
Prohibited	2902 (93.4)	0 (0.0)	936 (30.1)
Allowed/not regulated	0 (0.0)	0 (0.0)	713 (22.9)
Licensed	206 (6.6)	3108 (100.0)	1459 (46.9)
For Licensed Midwives[a]	n=206	n=3108	n=1459
Collaborative agreement required	206 (100.0)	1718 (55.3)	705 (48.3)
Medicaid reimbursement available	62 (30.1)	3108 (100.0)	495 (33.9)
Midwife required on board or council	62 (30.1)	965 (31.1)	1253 (85.9)
Physician supervision required	115 (55.8)	1240 (39.9)	92 (6.3)
Prescriptive authority			
Prohibited	8 (3.9)	95 (3.1)	368 (25.2)
Physician only	136 (66.0)	1422 (45.8)	349 (23.9)
Limited	0 (0.0)	381 (12.3)	432 (29.6)
Comprehensive	0 (0.0)	331 (10.7)	310 (21.3)
Full	62 (30.1)	879 (28.3)	0 (0.0)
Scope limited to childbearing year	0 (0.0)	0 (0.0)	1182 (81.0)
Scope includes well-woman care	206 (100.0)	3108 (100.0)	172 (11.8)
Statutory limitations to site of practice	136 (66.0)	2002 (64.4)	1459 (100.0)
VBAC allowance			
Prohibited/unregulated	3 (1.5)	1620 (52.1)	148 (10.1)
Allowed by restrictive conditions	83 (40.3)	297 (9.6)	235 (16.1)
Allowed by conditions	0 (0.0)	812 (26.1)	812 (55.7)
Unrestricted	120 (58.3)	379 (12.2)	264 (18.1)

[a]Proportion calculations only include counties in states where licensure is available for the indicated midwife credential, with n specified for each credential.

Licensure is available for midwives with the CNM credential in all contiguous states, entitling these providers to Medicaid reimbursement in all counties. In contrast, licensure for CPMs is prohibited in more than a quarter of counties (n=936, 30.1%), and Medicaid reimbursement is available to midwives with these credentials in about a third of the counties (n=495, 33.9%) where they can be licensed. In most counties where CPMs can be licensed (n=1,182, 81.0%), their scope of care is restricted to the childbearing year.

Table 8 contains descriptive details for covariates describing the demographics of overall and childbearing populations (females aged 15-50 years). There were no missing values for any county-level variable. Although 37% of counties (n=1,160) in the contiguous US are considered metropolitan, most counties (63%, n=1,948) have populations smaller than 50,000 people. As evidenced by the distributions of variables, childbearing populations are predominantly non-Hispanic White in most counties (median=81.4%); and a considerable proportion (median=17.2%) are estimated to be living below the federal poverty level.

Table 8. General and childbearing population demographics for all counties in the contiguous US (N=3,108).

Variable	**n (%)**
Urbanity classification	
Large central metro (>1m)	68 (2.2)
Large fringe metro (>1m)	368 (11.8)
Medium metro (250k-1m)	369 (11.9)
Small metro (50-250k)	355 (11.4)
Micropolitan (MSA <50k)	637 (20.5)
Noncore (non-MSA)	1311 (42.2)
	Median (IQR)
Black population proportion	2.3 (0.7-10.3)
NHW population proportion	83.9 (64.8-92.6)
Black childbearing population proportion	2.0 (0.4-11.3)
NHW childbearing population proportion	81.4 (61.2-91.6)
Non-native childbearing population proportion	3.7 (1.7-8.0)
Childbearing population proportion receiving public assistance in last year	1.7 (1.0-2.6)
Childbearing population proportion living below poverty level	17.2 (12.9-22.2)

IQR: interquartile range; MSA: Metropolitan Statistical Area; NHW: non-Hispanic White

3.4.4 Logistic regression for presence of a birth center

Tables 15-17 (Appendix) provide results from univariable regression of the three presence outcomes, with odds ratios (OR) reported for each exposure variable and covariate. Given that there was no variation in values representing statutory limitations on site of practice for licensed CPMs, this variable was excluded from all regression analyses.

Univariable regression revealed non-linear and plateauing relationships between county-level exposures to structural racism and birth center presence. Using the first quartile (Q1) as reference, Q2 values for the Black-NHW educational attainment and employment ratios (i.e., increased structural racism) were associated with significantly higher odds of all three presence outcomes at the county level. In contrast, Q4 values for both of these variables, indicating increased structural racism, were associated with significantly lower odds of all three presence outcomes. Compared to Q1, decreasing ICE values (Index of Concentration at the Extremes), indicating segregation that maximizes deprivation for the oppressed group (Black/African American), were associated with significantly higher odds of each presence outcome compared to Q1 counties.

Of the three indicator variables describing CPM scope of care (midwifery integration, VBAC allowance, and prescriptive authority for CPMs), VBAC allowance was the only one that seemed to have a non-linear univariable relationship with birth center presence. Odds of birth center presence associated with VBAC allowance did not seem to change considerably between quartiles. In fact, Q4 counties (unrestricted) were associated with lower odds than Q3 counties (allowed by conditions), using the first quartile as reference. In contrast, higher quartile values for midwifery integration and prescriptive authority were associated with significantly higher odds of birth center presence, with Q4 values being related to the highest odds ratios.

The following binary variables representing broader integration of CPMs were associated with significantly higher odds of birth center presence: CPM required on board; CPM providing services at birth centers; Medicaid reimbursement for CPMs; and CPM scope including well-woman care. On the other hand, variables representing increased restriction for CPMs were associated with significantly lower odds of birth center presence: collaborative agreement requirement for CPMs; CPM scope being limited to the childbearing year; and required physician supervision for CPMs.

County-level urbanity (i.e., population size) was significantly associated with all three outcomes in univariable models, with odds increasing between each classification tier, or as population size grows, indicating some linearity. Odds of birth center presence associated with large metropolitan counties (more than 1 million) were considerably higher compared to those associated with medium and small metropolitan counties (250,000-1 million and 50,000-250,000, respectively) and micropolitan and non-core counties (fewer than 50,000).

The next step before model-building involved reviewing the correlation matrix, which are provided in the Appendix (Tables 18 and 19) of all exposure variables and covariates to avoid including measures that are strongly associated in the same multivariable regression models. For these purposes, the threshold for strong association was $p<0.05$ (Kruskal-Wallis test) or $r > |0.50|$ (correlation tests). If needed, the decision to keep one of two strongly associated covariates was based on examining which had a stronger univariable association with the outcomes of interest (Table 14). In addition, the investigator used their discretion to remove variables with high levels of missingness (> 50%). The covariates retained for multivariable logistic regression included: educational attainment ratio (indicator variable); employment ratio (indicator); Index of Dissimilarity value (indicator); ICE value (Index of Concentration at the Extremes; indicator);

urbanity classification (indicator); CPM required on board (binary); VBAC allowance (indicator); collaborative agreement requirement for CPMs (binary); Medicaid reimbursement for licensed CPMs (binary); and prescriptive authority for CPMs (indicator).

Starting with the first outcome, the presence of any birth center at the county level, a multivariable model was run including all selected covariates. Covariates were retained for Model 2 if the odds ratio for at least one factor was significant ($p<0.05$). The following were then removed: income ratio; ICE value; CPM required on board; and prescriptive authority for CPMs. Each variable in the second model had at least one factor with a significant OR and thus was retained, requiring no further modeling. The results from the final logistic regression model for presence of any birth center at the county level are provided in Table 9.

Table 9. Association between county-level measures of structural racism and birth center presence, adjusting for midwifery scope and demographic variables in logistic regression.

	Adjusted Odds Ratio [95% Confidence Interval]
Exposure Variables	**Final Model – Birth center presence**
Educational attainment ratio[a, b]	
Quartile 1 (0.81-3.50)	REF
Quartile 2 (0.51-0.80)	**1.60 [1.07-2.41]**
Quartile 3 (0.21-0.50)	1.44 [0.91-2.27]
Quartile 4 (0.00-0.20)	0.64 [0.23-1.76]
Employment ratio[a, c]	
Quartile 1 (1.01-2.90)	REF
Quartile 2 (0.91-1.00)	0.99 [0.66-1.47]
Quartile 3 (0.71-0.90)	**0.58 [0.37-0.92]**
Quartile 4 (0.00-0.70)	**0.34 [0.15-0.74]**
Index of Dissimilarity[a, d]	
Quartile 1 (56.71-93.50)	REF
Quartile 2 (45.41-56.70)	**5.80 [3.04-11.08]**
Quartile 3 (33.91-45.40)	**6.61 [3.47-12.62]**
Quartile 4 (1.10-33.90)	**5.93 [3.02-11.66]**
Covariates	
Urbanity classification	
Noncore (non-MSA)	REF
Micropolitan (MSA <50k)	**2.41 [1.01-5.73]**
Small metro (50-250k)	**7.99 [3.45-18.50]**
Medium metro (250k-1m)	**12.94 [5.69-29.45]**
Large fringe metro (>1m)	**11.88 [5.20-27.14]**
Large central metro (>1m)	**57.39 [22.11-148.95]**
Collaborative agreement required	
Yes	**0.32 [0.23-0.44]**
Medicaid reimbursement for CPMs	
Yes	**5.62 [3.95-8.01]**

[a]Structural racism measures represent variables recoded as categorical to represent each quartile of values

[b]Educational attainment ratio is calculated for each county by dividing the proportion of Black people over 25 years old with a bachelor's degree by the proportion of non-Hispanic White people over 25 with a bachelor's

[c]Employment ratio is calculated for each county by dividing the proportion of Black people over 16 years old with employment by the proportion of non-Hispanic White people over 16 with employment

[d]Index of Dissimilarity values are determined for each county by calculating the difference between the relative distribution of Black and non-Hispanic White population proportions across census tracts within that county

CPM: Certified Professional Midwife; MSA; metropolitan statistical area; VBAC: vaginal birth after cesarean

In the multivariable model for presence of any birth center at the county level, Q2 values for educational attainment, representing increased structural racism, were associated with

significantly higher odds compared to Q1, adjusting for employment ratio, segregation (Index of Dissimilarity), urbanity, collaborative agreement requirement for CPMs, and Medicaid reimbursement for CPMs. Increased values for the Index of Dissimilarity, indicating increased segregation of Black and NHW populations, were also associated with significantly higher adjusted odds of birth center presence. In contrast, Q3 and Q4 values for the employment ratio, representing higher levels of structural racism, were associated with significantly lower adjusted odds of birth center presence.

The same model-building process described above was applied to predict the presence of a licensed birth centers and accredited birth centers at the county level. For both accredited and licensed centers, just two logistic regression models were necessary to reach a model where each variable had at least one factor with a significant OR. Tables 20 and 21 in the Appendix provide the results for these final regression models.

Both segregation indices were associated with odds of accredited birth center presence at the county level, adjusting for urbanity and prescriptive authority for CPMs, but these structural racism measures appeared to have different effects in the final multivariable model (Table 20). Increased values for the Index of Dissimilarity, indicating increased residential segregation, were associated with significantly higher odds of accredited birth center presence. While these odds appeared to peak for Q3 counties (OR=12.51), the confidence intervals for each quartile overlap considerably. On the other hand, counties with ICE values in Q2 were associated with significantly higher adjusted odds of accredited birth center presence, but this significance did not remain for Q3 and Q4 counties.

Regarding the final model referenced in Table 21, Q2 values for educational attainment, indicating higher levels of structural racism compared to Q1, were associated with significantly

higher odds of licensed birth center presence; this significance was lost for Q3 and Q4 values. In contrast, Q4 values for the employment ratio, indicating the highest levels of structural racism for this measure, were associated with significantly lower odds of licensed center presence at the county level. Increases in values for the Index of Dissimilarity, indicating increased racial segregation, were associated with significantly higher odds of licensed birth center presence at the county level, adjusting for urbanity, collaborative agreement requirement for CPMs, Medicaid reimbursement for CPMs, and prescriptive authority for CPMs. Once again, similar ORs and overlapping confidence intervals between quartiles for these two structural racism measures highlight the lower odds associated with Q1 values, but not odds that increase in proportion to values in higher quartiles. ICE values were also included in the final multivariable model for licensed birth center presence; Q3 and Q4 values, representing segregation that maximizes deprivation for the oppressed group (Black/African American populations) were associated with significantly lower odds compared to Q1 values.

3.5 DISCUSSION

This study was innovative in its analysis of structural racism measures in relation to birth center presence at the county level. Even so, the hypothesis that birth center locations in the contiguous US would be associated with indicators of systemic racial inequity was only partially supported. Increased values for the Index of Dissimilarity (i.e., increased residential segregation) were associated with significantly higher adjusted odds of each birth center presence outcome, supporting the hypothesis that birth center locations are related to an indicator of structural racism. Following this trend, increased values for the educational attainment ratio (increased structural

racism) were also associated increased adjusted odds of birth center presence, but significance was only maintained in comparing first and second quartiles.

On the other hand, decreasing employment ratio values were associated with significantly lower adjusted odds of birth center and licensed center presence. This finding contradicts the hypothesis, suggesting that birth center locations are related to increased racial equity regarding employment. Similarly, decreasing ICE values, indicating racial segregation that maximizes deprivation for the oppressed group, were associated with significantly lower adjusted odds of licensed birth center presence. At first glance, this finding does not support the hypothesis that birth centers are more likely to be in oppressed communities. However, it demonstrates that birth center locations are related to maximized privilege for the dominant group, non-Hispanic Whites, which still implicates some level of racial inequity. It is also important to consider that increased equity and residential segregation may coincide at the county level. In other words, these findings demonstrated how birth centers were more likely to be present in counties with higher levels of residential segregation, but also where employment rates and earned income were similar between Black and NHW populations.

The finding regarding increased racial equity in employment could indicate a bias in the measure itself – employment does not necessarily ensure equity. There is some literature describing racial stratification within professional fields, particularly for Black women.[134] In examining racial disparities in employment, it would likely be more insightful to investigate how types of employment and pay vary across demographic factors.

The significant associations between the variable representing the Black-White prisoner population ratio and all three outcomes of interest deserves mention, even if it was not included in multivariable regression analyses due to high missingness (52%) at the county level. In univariable

analyses, increased Black-NHW prisoner ratio was associated with significantly higher odds of any birth center, an accredited center, and a licensed center existing in a county, underscoring the main findings presented here that suggest a link between birth center locations and oppressed communities.

It is also important to highlight the significant associations between county-level urbanity and the outcomes of interest in multivariable regression models. The higher odds related to increasing urbanity, after controlling for related measures of structural racism and midwifery scope, demonstrate how birth center locations are driven by population size. This also indicates a considerable gap in access to birth center care for less urbanized (more rural) counties.

Although state-level variables describing midwifery autonomy were not outcomes of interest in the present study, the regression findings merit some discussion. In final multivariable models, broader prescriptive authority for licensed CPMs was associated with significantly higher odds of accredited and licensed birth center presence. The collaborative agreement requirement for CPMs was associated with significantly lower adjusted odds of presence in final multivariable models for any birth center or licensed centers. In addition, univariable models showed the odds of birth center presence to be positively associated with factors related to expanded autonomy for CPMs, and negatively associated with those related to restrictions for CPMs. Clinical education for CPMs typically occurs in the community setting (i.e., homes, birth centers),[130] which may help explain the association between their autonomy of care and birth center presence. Additionally, the CPM workforce appears to be more racially and ethnically diverse compared to that of CNMs/CMs. In 2020, the American Midwifery Certification Board reported that 86% of surveyed CNMs and CMs identify as White,[135] contrasting with an estimated 79% of CPMs in 2011.[130] Increasing representation from practitioners who identify as people of color (e.g., Black,

Indigenous) has been identified as an approach to reducing racial disparities in birth outcomes.[13] The findings presented here offer a foundation for scientific exploration of expanding autonomy of care for CPMs at the state level as a strategy to increase population-level access to birth center and midwifery models of care.

While this study adds highly valuable knowledge to the evidence base regarding birth centers and racial equity, it is not without limitations. First, regression analyses did not include statistical adjustments for multiple comparisons. Since this study consisted of multiple hypothesis tests, there was a higher probability of false inferences, or significant p-values that did not truly represent significant findings. For this reason, p-values were not reported in this study so as not to overstate the significance of findings. Instead, main results were reported as odds ratios and 95% confidence intervals. In addition, missingness among some measures of structural racism was a major issue, with rates ranging from 50-80% for some county-level variables (e.g., infant mortality rate). Since these values are likely missing due to low counts at the county level, thus not missing at random, imputation was inappropriate. All measures were included in univariable regression analyses, but some were removed in multivariable due to missingness. Lastly, there was a lack of intersectionality in the estimates made publicly available by the US Census Bureau. For example, the present study was unable to include county-level measures that capture intersecting identities, such as the population proportion of Black people with graduate degrees and living below the poverty level, or non-Hispanic White childbearing people with Medicaid insurance. Future research should utilize individual-level data that can be aggregated at higher levels, such as vital statistics data, to better describe the demographics of childbearing populations.

3.5.1 Implications

The findings presented here indicate a link between structural inequities (e.g., racial segregation) and birth center presence at the county level, even after controlling for state-level midwifery regulations (e.g., prescriptive authority for licensed CPMs). This study is cross-sectional, making it inappropriate to consider indicators of structural racism as predictive of a birth center's presence. Even so, the findings here demonstrate how systems-level inequities, some of which have persisted for decades, are related to where a birth center is located, and consequently its physical and social context. Research in medicine and public health that applies measures of structural racism is largely focused on relating these measures to health outcomes, rather than the geographic distribution of clinic locations, making the present research a novel contribution to the evidence base.

Although not hypothesized, the present findings also suggest that birth center locations are positively associated with large metropolitan counties. Since the evidence base does not indicate racial and socioeconomic diversity among birth center clientele,[6-8] disparate access to birth center care for oppressed populations remains unexplained. Study results highlight the imperative to examine contextual factors related to the care experience, particularly for Black childbearing people. Furthermore, birth center presence at the county level does not inherently mean access for all those living there. Investigating low representation of Black childbearing people in birth centers will require identifying service catchment areas and describing the populations therein.

4.0 DEMOGRAPHICS OF CHILDBEARING POPULATIONS IN SERVICE CATCHMENT AREAS FOR EXISTING BIRTH CENTERS, 2015-2019

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4.1 ABSTRACT

Background: Although key evidence indicates racially disparate engagement with birth center care in the US, with clientele being predominantly non-Hispanic White, there is minimal insight in the health literature regarding the demographic composition of childbearing populations with ostensible access to these facilities. The objectives of this study include identifying service catchment areas for existing birth centers in the contiguous US and describing the demographics of the childbearing populations in those areas.

Methods: This study utilizes spatial methods to identify census tracts within 45 minutes' driving of an existing birth center in the contiguous US. In addition, statistical testing is applied to compare the demographics of childbearing populations within identified catchment areas to those outside.

Results: Compared to census tracts outside of birth center catchment areas, the findings demonstrated these facilities to be located in demographically diverse areas, with higher proportions of childbearing people that identify as Asian, Black, and Hispanic. No significant differences were found in the racial make-up of tracts within catchment area zones, defined by driving time.

Discussion: Contrary to the hypothesis, birth centers in the US tend to have demographically diverse catchment areas. The evidence base for birth centers does not indicate similar levels of diversity among clientele. Consequently, the findings call for the investigation of contextual factors, other than geographic proximity, that may be related to racially disparate engagement with birth centers, such as eligibility screening and care experience.

4.2 INTRODUCTION

In the United States, rates of adverse perinatal outcomes are persistently disparate between Black and White childbearing people, with the former group experiencing the highest rates of pregnancy-related mortality (e.g., due to cardiovascular condition, pre-existing illness) and infant mortality (death before one year of age) compared to all other racial and ethnic groups.[1] Recent data from the Centers for Disease Control and Prevention (CDC) showed an infant mortality rate of 10.8 per 1,000 live births for non-Hispanic Black people, compared to a rate of 4.6 for non-Hispanic Whites, representing a Black-White ratio of approximately 2.3.[2] The CDC also reported a pregnancy-related mortality rate of 42.4 deaths per 100,000 live births for non-Hispanic Black populations between the years 2011-2016, compared to 13.0 per 100,000 for their White counterparts.[3]

A potential approach to improve outcomes for Black childbearing people and their infants is increased use of birth center care. Over the last 40 years, research has demonstrated that birth center care is associated with considerably better outcomes for childbearing people of all socioeconomic and racial groups compared to national statistics.[6-9] Given that birth centers are typically led by midwives, often with the consultation of collaborating physicians, the literature attributes these improvements to elements unique to the midwifery care model, such as increased time spent with providers, emphasis on perinatal education and shared decision-making, and application of evidence-based interventions only when indicated.[8,11]

The current evidence to gauge Black people's access to birth center care is limited. Recent multi-center studies indicated that Black clients represented an estimated 6% of a national sample eligible for birth center birth[6] and an estimated 12% of a sample of Medicaid beneficiaries who gave birth with a participating birth center,[8] despite representing about 15% of the childbearing

population in the US. Vedam et al. found the birthrate among Black childbearing people to be inversely correlated with midwifery integration scores; in other words, midwives tend to be more integrated into perinatal care systems in areas with fewer Black births.[38] This finding may also help to explain the disproportionate representation of Black birthing people in birth centers, which are often midwife-led.

The limited literature that explores decision-making around planned birth site does not indicate racially different perceptions of community birth. One multi-site, cross-sectional study[50] demonstrated that Black people view community birth just as positively as White people. Another study examined racial differences in perspectives on vaginal versus surgical birth; investigators found no significant differences between Black and White participants.[51] Since an estimated 85% of pregnancies are considered medically low-risk and likely eligible for birth center care,[6] it is imperative to understand population-level access to this model – including why access for some childbearing individuals is reduced. Methods using GIS (geographical information systems) present accessible and foundational approaches to understanding population-level access to birth center care.

In the literature on measuring spatial access to desired care, the two-step floating catchment method is named as an ideal approach,[136,137] since it considers both accessibility (geographic proximity) and availability (provider-to-population ratio). However, birth centers are not nearly as numerous as primary care practices, making this more sophisticated approach unnecessary. In 2020, the American Association of Birth Centers (AABC) estimated fewer than 400 birth centers in 37 states.[72] For the present study, it is more appropriate to assume that provider choices for those seeking birth center care are limited, likely to no more than a single birth center if any at all. This

approach is akin to studying care access in rural areas, where it is suitable to address only accessibility and not availability.[137]

The present study aims to describe the demographic make-up of childbearing populations in birth center catchment areas in the contiguous US as well as compare the demographics of childbearing populations within catchment areas across zones of travel time. It is predicted that birth center catchment areas will have significantly larger non-Hispanic White childbearing population proportions compared to non-catchment areas at the census tract level; and that population proportions of Black childbearing people residing in catchment areas will be overrepresented in the furthest zone compared to non-Hispanic White counterparts.

4.3 METHODS

4.3.1 Study Design and Setting

The present study utilized secondary and public data from two sources: US Census Bureau (2019 American Community Survey) and the AABC. Building on the decennial census, measures within the American Community Survey (ACS) are calculated every year, for one- and five-year periods, and consist of many of the same population estimates as the decennial census. Originally named the Cooperative Birth Center Network, founded in 1981, the AABC continues to serve as a professional advocacy organization for birth center clinicians and staff.[72]

Using GIS (geographic information systems) software and statistical analyses to identify service catchment areas for birth centers in the contiguous US (48 states and Washington, DC), the findings from this study describe the demographic make-up of childbearing populations in

these catchment areas at the census tract level as well as the linear relationship between these demographic estimates and driving distance (miles) and time (minutes) at the tract level. The US Census Bureau defines a census tract as stable subdivision of a county or other municipality; tract boundaries are updated with each decennial census. Optimally, tracts have a population size of about 4,000 people, but may range from 1,200-8,000 people.

This protocol was approved as exempt from review by the Institutional Review Board of the Human Research Protection Office at the University of Pittsburgh.

4.3.2 Measures

The present study utilized a list of birth centers (N=479) that were open for all or some of the 2015-2019 period, which was provided by the AABC after their Board of Directors approved the data use proposal in December 2021. This list included the following data: mailing addresses for geocoding, current licensure and accreditation status, and longevity of the practice (in years). Birth centers were removed from the dataset if they had addresses outside the contiguous US (n=17), represented duplicate addresses (n=11), or no address was provided (n=6). Using this analytic sample of birth centers (N=445), facility addresses were geocoded in QGIS using the OpenStreetMap feature. Awesome Table[123] was used to geocode 70 facility addresses that could not be found using the first tool.

Using the five-year estimates from the 2019 ACS fertility tables, demographic data are linked to each tract within a birth center catchment area, whose determination is detailed in next section. Table 10 details the variables pulled from the ACS for childbearing populations at the tract level.

Table 10. Variables pulled from the 2019 American Community Survey (five-year estimates) to describe childbearing populations (females aged 15-50 years) at the census tract level.

Variable	Values
Age	Percent 15-19 years old; percent 20-34 years old; percent 35-50 years old
Educational attainment	Percent with less than high school; percent with high school graduation/GED; percent with a Bachelor's degree
Nativity	Percent born in the US
Poverty	Percent living below the 100% poverty level
Public assistance	Percent receiving public assistance benefits in the last year
Race & ethnicity	Percent American Indian/Alaska Native; percent Asian; percent Black/African American; percent Hispanic; percept Native Hawaiian or other Pacific Islander; percent non-Hispanic White

GED: Tests of General Education Development

4.3.3 Travel burden assessment

The present study used QGIS (Version 3.10)[122] for geocoding and travel burden assessments as well as Stata SE (Version 16.1)[133] for recoding variables and merging datasets. Publicly accessible shapefiles, representing all tracts in the contiguous US (48 states and Washington, DC), were retrieved from the US Census Bureau website, and uploaded to QGIS. Centroids were generated for each tract, serving as proxies of residence for the childbearing populations in that area.

TravelTime is a plug-in for QGIS that uses an algorithm to calculate driving distance (meters) and time (seconds) between selected geographic coordinates. In this study, TravelTime was utilized to designate tract centroids as "reachable" if they were within 45 minutes' driving from the geocoded location of each birth center. The parameters for the plug-in were set to measure driving distance and travel time to arrive at a birth center on Wednesday, January 26, 2022, at 12:00 PM, within 45 minutes. This date and time were selected to avoid higher traffic times, such as rush hour.

In Stata, a merged dataset was created containing the tracts from all birth center catchment areas. Driving distance and time determined by TravelTime were then converted into miles (divide meters by 1609) and minutes (divide seconds by 60), respectively. Additionally, tracts in overlapping catchment areas were identified in Stata, and a count variable was generated representing how many times each tract appeared in the catchment area for more than one center. Once all tracts included in at least one catchment area were identified, they were linked with tract-level ACS data describing childbearing populations (Table 10). An additional categorical variable was generated to designate tracts that were within zone 1 of a birth center's catchment area (< 15 minutes' driving); zone 2 (15-30 minutes' driving); and zone 3 (> 30 minutes' driving).

4.3.4 Statistical Analyses

From the merged data, a dataset was created to compare tracts in birth center catchment areas (within 45 minutes' driving from the tract centroid to the center location) to those in non-catchment areas (more than 45 minutes' driving). In addition to describing the distributions of childbearing demographics in catchment and non-catchment areas, independent *t* tests were conducted and reported on for each variable to determine significant differences.

Next, summary statistics were generated to describe birth center catchment areas in the analytic sample. For example, average driving distance for all birth center catchment areas was calculated as the mean value of driving distance (miles) for all tracts in a catchment area; and average childbearing population proportion with a bachelor's degree was calculated as the mean percent value for all tracts in a catchment area. The distributions of these aggregate statistics were reported overall and by catchment area zone (based on driving time). Finally, ANOVA testing was

conducted in Stata to determine significant differences ($p<0.05$) in childbearing demographics between each catchment area zone.

4.4 RESULTS

4.4.1 Birth center catchment areas

The merged dataset containing tracts for all birth center catchment areas included 156,776 observations, 90% of which (n=141,338) represent tracts in multiple catchment areas. Duplicate tracts appeared in overlapping catchment areas for a range of 1-29 birth centers (median=5). Using this process for defining catchment areas in QGIS, none was identified for a birth center in Utah, so this observation was removed from the dataset for subsequent statistical comparisons.

Figure 5 illustrates all tracts within the catchment area of at least one birth center in the contiguous US. Geographically, the largest coverage areas appear in central Florida, Michigan, Minnesota, eastern Texas, Wisconsin, and in states along the mid-Atlantic coast. Gaps of note include the lack of birth center catchment areas that reach states in the Midwest (e.g., North Dakota, South Dakota), in Nevada, or in the South (e.g., Mississippi).

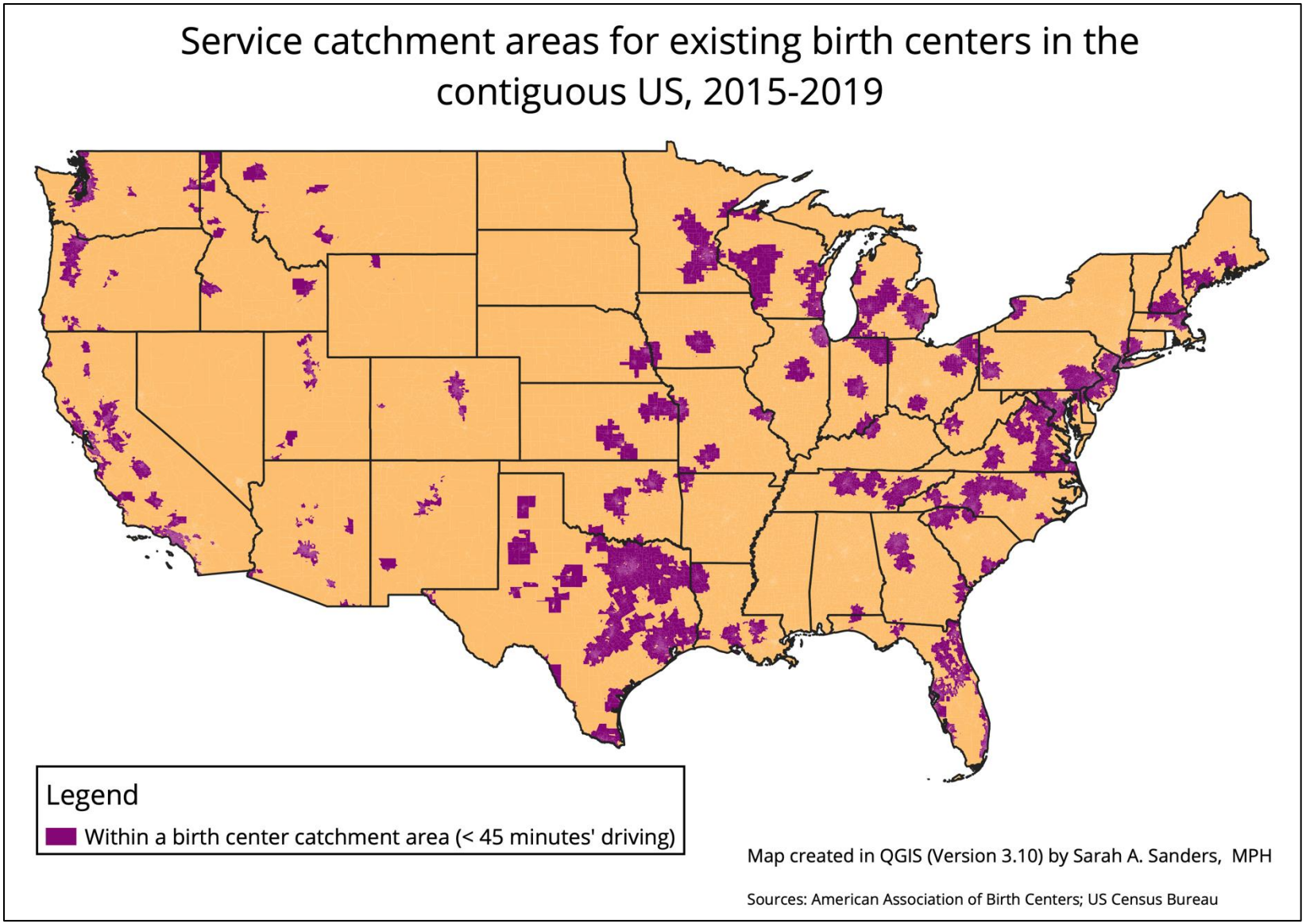

Figure 5. Map of census tracts in the contiguous US that are within the catchment area of at least one existing birth center from 2015-2019.

Approximately 59% (n=43,404) of tracts in the contiguous US fall within a birth center catchment area, as it was defined here. These were compared to tracts in non-catchment areas (n=29,795) using independent *t* tests for each variable describing childbearing demographics. Table 11 provides the mean and standard deviation for each variable as well as the p-value from comparative testing, all of which were statistically significant ($p<0.05$).

Table 11. Comparison of childbearing demographics for census tracts in birth center catchment areas (n=43,404) and non-catchment areas (n=29,795), with significance values from t tests.

	Catchment Area CT	**Non-Catchment CT**	***t* test p-value**
	Mean (SD)		
Age			
15-19 years old (%)	12.7 (7.1)	13.8 (7.2)	<0.0001
20-34 years old (%)	43.2 (12.1)	41.7 (11.0)	<0.0001
35-50 years old (%)	44.2 (10.8)	44.5 (10.5)	<0.0001
Educational attainment			
Less than high school (%)	16.6 (10.1)	17.0 (9.0)	<0.0001
High school/GED (%)	19.9 (10.8)	24.0 (10.5)	<0.0001
Bachelor's degree (%)	21.7 (12.4)	16.6 (10.1)	<0.0001
Race and ethnicity			
AIAN (%)	0.7 (2.3)	1.5 (7.5)	<0.0001
Asian (%)	7.7 (11.6)	3.0 (6.7)	<0.0001
Black/AA (%)	15.7 (23.3)	12.2 (21.1)	<0.0001
Hispanic (%)	22.2 (24.5)	14.0 (22.8)	<0.0001
NHOPI (%)	0.2 (1.0)	0.2 (1.8)	<0.0001
NHW (%)	51.6 (30.4)	67.4 (29.8)	<0.0001
Socioeconomic status			
Received public assistance benefits in last year (%)	2.0 (3.2)	2.4 (3.6)	<0.0001
Living below poverty level (%)	15.0 (12.5)	18.8 (14.2)	<0.0001

AA: African American; AIAN: American Indian or Alaska Native; ANOVA: analysis of variance; GED: tests of General Education Development; NHOPI: Native Hawaiian or other Pacific Islander; NHW: non-Hispanic White; SD: standard deviation

These results indicate that childbearing populations living within birth center catchment areas are significantly more likely to be 20-34 years old; have a bachelor's degree; and identify as

Asian, Black, or Hispanic, compared to those living outside catchment areas (> 45 minutes' driving from a birth center). On the other hand, catchment area populations have significantly smaller proportions of childbearing people under 20 years or older than 35 years, those with less than a high school education, those who identify as Native American or non-Hispanic White, those who have received public assistance benefits in the last year, and those who live below the poverty level.

On average, birth center catchment areas in the contiguous US contained 353 tracts. Average driving distance and time from tract centroids to birth center locations were about 19 miles and 26 minutes, respectively. Table 12 provides descriptive data derived from the collapsed dataset of birth center catchment areas (n=444) containing summary statistics by center, as well as results from ANOVA testing that compares the zones defined by driving time to a birth center. Results show that childbearing populations across the catchment area zones differ significantly by age, educational attainment, and poverty status. None of the race and ethnicity variables or the public assistance variable differed significantly across zones.

Table 12. Summary statistics for all birth center catchment areas (n=444), and by catchment area zone (based on driving time), with significance values from ANOVA tests comparing zones.

	Overall[a]	Zone 1 (<15 min)	Zone 2 (15-30 min)	Zone 3 (30-45 min)	ANOVA p-value
	Mean (SD)				
Age					
15-19 years old (%)	13.2 (1.8)	13.0 (3.1)	13.2 (2.5)	13.7 (2.4)	0.0006
20-34 years old (%)	43.4 (2.8)	45.0 (5.6)	42.6 (3.8)	41.5 (4.0)	<0.0001
35-50 years old (%)	43.4 (3.0)	42.0 (5.7)	44.2 (3.6)	44.8 (3.4)	<0.0001
Educational attainment					
Less than high school (%)	17.4 (4.3)	17.0 (6.4)	17.4 (4.8)	18.0 (4.9)	0.0280
High school/GED (%)	20.9 (4.2)	20.3 (5.9)	20.8 (4.8)	21.5 (5.0)	0.0058
Bachelor's degree (%)	20.0 (5.3)	20.4 (7.5)	20.2 (5.8)	19.2 (5.9)	0.0173
Race and ethnicity					
AIAN (%)	1.0 (1.5)	0.9 (1.3)	1.0 (2.4)	1.1 (2.2)	0.3959
Asian (%)	5.6 (5.7)	5.5 (6.3)	5.5 (6.3)	5.3 (5.9)	0.7678
Black/AA (%)	10.6 (10.0)	11.1 (12.3)	9.9 (10.1)	9.4 (10.1)	0.0702
Hispanic (%)	24.9 (20.4)	24.3 (20.8)	23.9 (20.4)	24.2 (20.7)	0.9631
NHOPI (%)	0.2 (0.4)	0.2 (0.3)	0.2 (0.4)	0.2 (0.4)	0.5894
NHW (%)	55.7 (21.2)	55.9 (22.1)	57.5 (22.8)	57.9 (22.2)	0.3991
Socioeconomic status					
Received public assistance benefits in last year (%)	2.0 (1.1)	2.0 (1.4)	1.9 (1.1)	1.9 (1.2)	0.3035
Living below poverty level (%)	16.1 (4.7)	17.0 (6.8)	14.8 (4.8)	15.4 (5.8)	<0.0001

[a]To be clear, ANOVA analyses did not include overall descriptive statistics.
AA: African American; AIAN: American Indian or Alaska Native; ANOVA: analysis of variance; GED: tests of General Education Development; NHOPI: Native Hawaiian or other Pacific Islander; NHW: non-Hispanic White; SD: standard deviation

4.5 DISCUSSION

This study represents the first systematic identification of service catchment areas for existing birth centers in the contiguous US. Results from statistical comparisons negated both research hypotheses, however, indicating that birth center catchment areas were composed of racially heterogenous childbearing populations, with no significant racial differences between catchment area zones. This suggests a demographic mismatch between the childbearing

populations that give birth with birth center midwives[6-8] and those that ostensibly have access to birth centers. Furthermore, these findings set the stage for scientific investigation of factors, other than geographic proximity, that may be associated with racially disparate access to birth center care.

Landmark studies of birth center care have focused on the labor phase and/or time of birth,[6,8] subsequently excluding people who register for care but eventually leave the practice, thus overlooking their care experience. The literature describing disparate quality of perinatal care for demographic subgroups is emerging but is especially limited in the context of birth centers or community birth. Two previous studies have reported racial differences in transfer from birth center care, with Black clients being overrepresented among transfers, but underlying issues remain unexplained.[78,138] Evidence shows that Black, Hispanic, and Indigenous childbearing people are most likely to report higher levels of medical mistreatment or receiving lower-quality care, compared to other groups.[53,55-57,84] The Giving Voice to Mothers study demonstrated how indicators of low socioeconomic status, such as living below the poverty level and receiving public assistance, were also associated with experiencing mistreatment or receiving lower quality care.[57] One study using a piloted instrument that was administered to birth center clients found no significant racial differences regarding the care experience.[5] Future investigations of birth center access should consider factors related to the care experience, from registration to giving birth, to help explain demographic disparities in representation.

Another related avenue for further investigation is the intake process by which birth centers screen childbearing people for care eligibility. This process varies across birth centers, often including clinical and social factors, and impacts who is accepted or retained as a client. Several clinical factors are related to eligibility for – and thus access to – birth center care, such as previous

cesarean, type 2 diabetes, or chronic hypertension.[6] Standards established by the Commission for the Accreditation of Birth Centers are relatively general, giving centers more liberty in determining how they want to screen potential clients.[139] Though flexible, this approach may enable screening practices that are discriminatory, even if implicitly so. In addition, intake may be constrained by state-level variation in the autonomy of birth center midwives, impacting how they can serve clients with complicated medical histories, such as a previous cesarean birth.[38] Studying the role of birth center differential intake processes seems paramount in the investigation of disparities in access to this model of care. Future research should also consider factors of reproductive history, particularly those that relate to intake screening or require a broader scope of care.

Lastly, the impact of insurance coverage on access to birth center care deserves some discussion. This study demonstrated that birth center catchment areas consist of significantly larger proportions of childbearing people living below the poverty level. Furthermore, comparison of catchment area zones indicated that poverty-stricken childbearing populations closest to birth centers (zone 1) were significantly larger. However, it is difficult to make direct comparisons between present findings and the evidence base regarding childbearing people with Medicaid insurance, as Medicaid benefits are not specified in the data pulled from the ACS. Even so, it is likely that childbearing populations living below the poverty level face more barriers to insurance coverage, especially for birth center care.

Recent data from all sites of the Pregnancy Risk Assessment Monitoring System (PRAMS) estimated that 36% of pregnant people use Medicaid coverage.[92] In 2019, it was estimated that 65% and 59% of births to non-Hispanic Black people and Hispanic people, respectively, were financed by Medicaid, compared to 29% of births to non-Hispanic Whites.[93] Most existing birth centers are not credentialed with state Medicaid payors. In its 2016 survey of existing birth centers,

the American Association of Birth Centers reported that just 28 facilities (21%) hold contracts with Medicaid payors that reimburse for a bundled fee, which typically covers midwifery care during pregnancy and use of the facility for labor and birth.[96] More centers report receiving reimbursement from Medicaid payors for only the facility fee (48%), which covers labor and birth expenses, such as nursing care and supplies, or only the professional fee (69%), which covers prenatal, labor, birth, and postpartum care given by midwives.[96] Insurance coverage is a major determinant of access to American health care generally and further research examining its impact on birth center access is warranted.

While this study has illuminated valuable information describing birth center catchment areas, it is not without its limitations. First, this study defined birth center catchment areas as census tract centroids being within 45 minutes' driving of the coordinates for an existing facility, thus excluding tracts that are further away. Examining a broader catchment area (e.g., 90 minutes' driving) is likely to produce different findings regarding the associations between tract-level demographics and travel burden to a birth center. Even so, the present investigation assumed that fewer childbearing people would be willing to drive more than 45 minutes to a birth center, making any interpretations about more distant populations less useful.

Second, this study did not consider traveling via public transit, which may be the only transportation option for many childbearing people in the contiguous US, particularly in large metropolitan areas. The present findings assume that all childbearing populations have access to a vehicle for transportation, potentially overstating the degree of access to birth center care for different demographic groups at the tract level. However, public transit networks do not exist in many parts of the contiguous US, or are not equally accessible by all childbearing populations, which would further complicate interpretation of findings.

Lastly, this study did not include a reliability assessment of identifying birth center catchment areas using travel time determinations. Ideally, this would consist of a sensitivity analysis comparing the present driving time values to those generated using different date and time parameters in the TravelTime plug-in. Even so, it is unlikely that different parameters would have identified catchment areas with distinctly different demographic compositions from what was presented here.

4.5.1 Implications

The present study is innovative in its analysis of secondary data to illustrate birth center catchment areas in the contiguous US, which consisted of significantly larger proportions of childbearing populations that identified as Asian, Black, and Hispanic compared to areas outside (> 45 minutes' driving). This differs from the evidence base describing birth center clientele,[6-8] highlighting the need to examine other contextual factors related to racially disparate access. The findings here serve as an excellent foundation for future research using vital statistics data to better understand how demographics intersect with medical histories to influence population-level access to birth center care.

At the organizational level, these findings also illuminate gaps in engagement for existing birth centers in the contiguous US. Although accreditation standards may require birth centers to assess and describe their service community demographics,[139] methodological approaches to this are unclear and may be inconsistent or lack fidelity. Even for birth centers not seeking accreditation, these findings present actionable opportunities to intervene on access gaps and engage childbearing populations in their service communities more equitably.

5.0 DISCUSSION AND CONCLUSIONS

5.1 DISCUSSION

5.1.1 Clustering of counties with birth centers in the contiguous US

Research around access to birth center care is scarce in the public health literature, despite a consistent evidence base that demonstrates optimal health outcomes for childbearing people and infants cared for in these facilities.[6-10] This dissertation represents the first known investigation to examine spatial clustering of birth center locations in the contiguous US, providing a solid foundation on which to base future programmatic and policy efforts regarding access to this model of care and its role in alleviating persistent racial inequities in birth outcomes.

Paper 1 demonstrated significant spatial autocorrelation of counties with at least one birth center the contiguous US between 2015-2019. Significance remained in global Moran's I analyses of counties with at least one accredited center, licensed center, and center that opened after 2010. Maps highlighted geographical gaps in birth center locations, potentially indicating reduced access to this care for childbearing populations in southern states, which are predominantly Black, as well as for those in rural, midwestern states. In addition, local Moran's I testing in Paper 1 identified dozens of hot spot counties where a birth center's presence is associated with higher odds of another's presence in a neighboring county, largely concentrated along the western and Gulf coasts. This may be partially explained by large metropolitan cities in these areas, such as Houston, Los Angeles, and Seattle.

Paper 2 demonstrated how state-level factors regarding midwifery scope of care were associated with geographic variation in birth center presence. Results in Paper 2 showed a significant increase in adjusted odds of a birth center existing in a county associated with broader prescriptive authority for licensed CPMs. In a state like Colorado, for example, where CPMs are totally prohibited from prescribing medications, broadening this scope to include a limited schedule of medications is significantly associated with a three-fold increase in odds of birth center presence at the county level. Several other CPM-related variables showed significant univariable associations with birth center locations in Paper 2, identifying broadened autonomy of care for these providers as a potential strategy for expanding the birth center model.

5.1.2 Demographic diversity in counties with birth centers

Birth centers tend to be in counties with racially diverse childbearing populations, as evidenced in this dissertation. The findings from Paper 3 indicated that birth center catchment areas (within 45 minutes' driving) had larger Asian, Black, and Hispanic childbearing populations compared to those outside catchment. Considering the demographic descriptions of birth center clientele in landmark studies, which are more demographically homogenous,[6,8] these findings invite further investigation of racially disparate engagement with birth center care.

In addition, analyses in Paper 3 revealed that the racial and ethnic makeup of childbearing populations at the census tract level did not differ significantly across three catchment area zones, defined by driving time to the birth center. In other words, driving proximity within birth center catchment areas did not appear to be associated with the racial composition of childbearing populations. Some significant differences were identified within catchment area zones by age

group, educational attainment, and poverty status of childbearing populations, but the absolute differences between zones were minimal.

5.1.3 Identified gaps in access to birth center care

While the hypotheses predicting birth center presence to be significantly associated with privileged childbearing populations (e.g., non-Hispanic White) were not supported, the findings in this dissertation research highlight gaps in access to birth center care. As described above, Paper 1 revealed significant spatial clustering of birth centers along western and southeastern borders of the contiguous US, highlighting large regions of the South and Midwest where very few birth centers are located. Between 2015-2019, birth centers were located in an estimated 9% of US counties. Identifying and mapping birth center catchment areas in Paper 3 further emphasized these care gaps, with an estimated 41% of census tracts (n=29,795) in the contiguous US being more than 45 minutes' driving from the nearest birth center.

Considering facility-level attributes like licensure and accreditation, often required by insurance payors for service reimbursement, Paper 1 also illustrated how spatial clustering may broaden gaps in access to birth center care, particularly for under- and uninsured childbearing populations. Licensure is not available for birth centers in 10 states, effectively nullifying the federal mandate within the Affordable Care Act requiring Medicaid programs to reimburse for services at licensed centers. In states where facility licensure is optional for operation, some insurance payors may accept accreditation instead of licensure.[96] There is no comprehensive understanding of insurance payors that require birth center accreditation to reimburse for services, but it is likely that lack of accreditation limits the affordability of care for many childbearing people, even with insurance coverage. Given that cost is one of the primary barriers to accreditation

reported by birth centers,[96] a feedback loop is produced where lack of accreditation reduces access and revenue, which further diminishes a center's resources to pursue accreditation.

5.1.4 Relating structural racism to birth center presence

Paper 2 was innovative in its application of structural racism measures in relation to birth center presence at the county level; and because it extended the application of these measures to the study of birth center growth, as opposed to perinatal health outcomes. Adjusting for variables related to midwifery autonomy and population density, the regression results in Paper 2 demonstrated how educational attainment and employment ratios, as well as residential segregation, all comparisons of Black and NHW populations, were significantly associated with birth center presence at the county level, though in opposite directions.

However, the interpretations of some of these findings conflict and significance may be spurious as there were no statistical adjustments for multiple comparisons. Reduced racial equity in educational attainment was associated with significantly higher odds of birth center presence, controlling for CPM autonomy variables and population size, a finding that supports the hypothesis. On the other hand, employment ratios indicating lower rates of employment among Black individuals compared to NHW (i.e., reduced racial equity) were associated with lower adjusted odds of a birth center existing in a county. Previous investigations examining the role of racial inequity in employment have demonstrated association with rates of infant mortality and SGA births (small-for-gestational-age), but the findings are mixed.[103,106] For example, contrary to their hypothesis, Wallace, et al., found a negative association between infant mortality and the Black-White ratio in employment using a national dataset.[106] Although straightforward in its determination, the variable used to represent systemic racial inequity in employment in Paper 2

may be too simplistic. Types of employment (e.g., managerial, entry-level) held by demographic subgroups, as well as income, should also be considered in developing appropriate measures of structural racism.

Previous studies have shown significant, negative associations between Black-White segregation and infant mortality rates.[101,109,110] Although Paper 2 did not examine a health outcome, parallel conclusions can be drawn suggesting that racial privilege is linked to optimal perinatal health. Just as low infant mortality rates mirror racial segregation, so do the locations of birth centers, or facilities consistently associated with reduced rates of adverse birth outcomes.[6,8,118] Put another way, the present findings demonstrate how structural racism may be marked by increased privilege for racial subgroups, just as it is by increased oppression.

5.2 CONCLUSIONS

While it may be intuitive that birth center locations follow trends in population density, with significant spatial clustering along the borders of the contiguous US and around metropolitan areas, the optimal health outcomes associated with this care model implore its expansion to all childbearing populations. In 2010, fewer than half a percent of all births in the US occurred in a birth center, [71] even though an estimated 85% of all pregnancies are low-risk and likely eligible for birth center care.[6] Although the present findings can offer only a broad glance at population-level access to birth center care, multiple opportunities for intervention are identified, as well as avenues for future research.

5.2.1 Expansion of birth center care centered on the margins

On one hand, the research here did not indicate geographical proximity as a main driver of differential access to birth center care for childbearing populations along racial and ethnic lines. On the other, disparities in diverse racial and ethnic representation among birth center clientele persist, implicating other factors that result in over-representation of childbearing people that identify as non-Hispanic White. In accordance with principles of PHCRP,[41] it is imperative to center the investigation of access to birth center care on Black childbearing people, who experience the worst perinatal health outcomes compared to other racial groups.[1,42,64,65]

Historically, research has focused on individual-level factors in studying perinatal care access and outcomes, such as clinical history, health behaviors, and socioeconomic status.[23,46,63,86] However, recent studies highlight context as an equally important and influential factor that helps to explain racial disparities.[23,44,45] In addition to examining the impact of discrimination-related stressors on perinatal health,[30,31,46,47,88] investigators have also studied the patient-provider relationship. Perceived mistreatment and cultural insensitivity have been consistently cited by Black childbearing people as barriers to establishing a trusting relationship with their provider.[34,53,55-57] While one study suggests that these experiences are less common in birth centers,[57] this issue deserves more attention within the study of disparate access and outcomes.

The limited literature examining issues of race in the birth center context points to centering marginal populations and cultural diversity as strategies for increasing engagement with Black childbearing people and improving care outcomes and experiences for all.[16,17,77,132] Case studies of the Family Health and Birth Center, established in Washington, DC in 2000, and the Roots Community Birth Center (Roots), established in Minneapolis in 2015, explain how both facility locations were deliberately selected, based on racial and socioeconomic diversity.[16,77]

Furthermore, the centers were strategic in efforts like credentialing with Medicaid[16] and integrating pediatric services[77] to better serve their clientele. The details from these case studies are underscored by findings from a recent quantitative study, which demonstrated that clients receiving culturally-centered care at Roots reported significantly higher levels of autonomy and respect compared to a national sample.[132] The findings from Paper 3, demonstrating that birth center catchment areas are more racially heterogenous compared to areas outside, may suggest that other birth center locations were selected to better serve more diverse and urbanized communities, as described in the aforementioned case studies.[16,77] More research examining the factors that influence birth center location selection is warranted to confirm this interpretation, however.

By anchoring the expansion of birth center care on the needs of Black childbearing people in the US, policymakers and stakeholders could not only contribute to reducing racial disparities in perinatal care access and outcomes, consequently, but also facilitate care models that better serve all childbearing people.

5.2.2 Imperative to research community birth

More than 98% of births in the US occur in a hospital each year, despite an estimated 85% of pregnancies being medically low-risk and likely eligible for birth center care and delivery.[6,140] Given the demonstrated benefits of this care model, including high client satisfaction, the limited coverage in public health and health policy literature is problematic. The dissertation research presented here contributes valuable information regarding population-level access to birth center care, but many questions remain that could be addressed, often with secondary data.

Managed by the AABC, the Perinatal Data Registry™ (PDR) houses longitudinal data from participating birth centers, including nearly 200 data points from the first prenatal visit to the

postpartum period. As a validated tool specifically designed for use by midwives and in birth centers, the PDR offers a wealth of secondary data that could address many of the research questions raised in this dissertation.[141] Supplementing individual-level data in the PDR, the AABC has also surveyed birth centers in the US and its territories to glean more information about facility operations, staffing structures, and student midwife training.[96]

Vital statistics data should also be leveraged to describe birth center catchment areas, as well as registered clientele at existing birth centers. The PDR provides valuable information about demographics and care outcomes at participating centers, but these only account for an estimated 26% of the facilities included in present analyses. In addition to site of birth, birth certificate data include clinical information relevant to medical risk assessments and birth center eligibility. Since birth centers differ regarding provider autonomy (e.g., VBAC allowance), due to state-level variation in regulations, clients' clinical histories become even more important in studying population-level access.

Although birth centers are largely considered alternative birth sites, stakeholders strongly suggest the equitable expansion of this model of care to properly serve the estimated 85% of childbearing people that experience low-risk pregnancies.[140] This not only requires data surveillance mechanisms to monitor outcome trends and identify disparities, but also targeted empirical research that provides a deeper understanding of birth center access for childbearing people. The evidence base indicates improved perinatal health outcomes for all demographic groups receiving birth center services, so the tasks at hand become getting more people to the door of a birth center and facilitating their stay as a client.

Appendix A – Paper 1

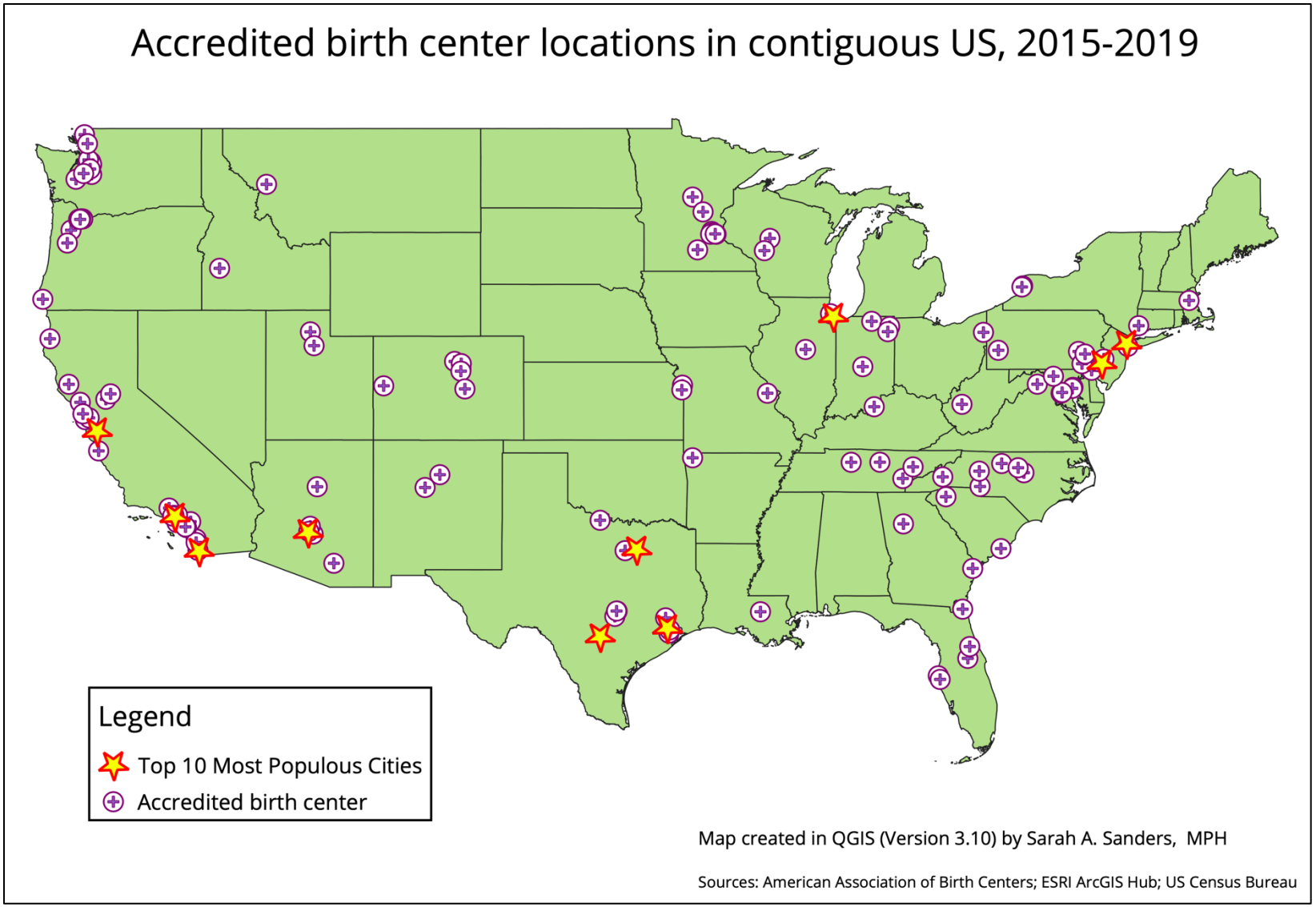

Figure 6. Map of accredited birth centers (n=124) in the contiguous US, overlaid with the top 10 most populous cities.

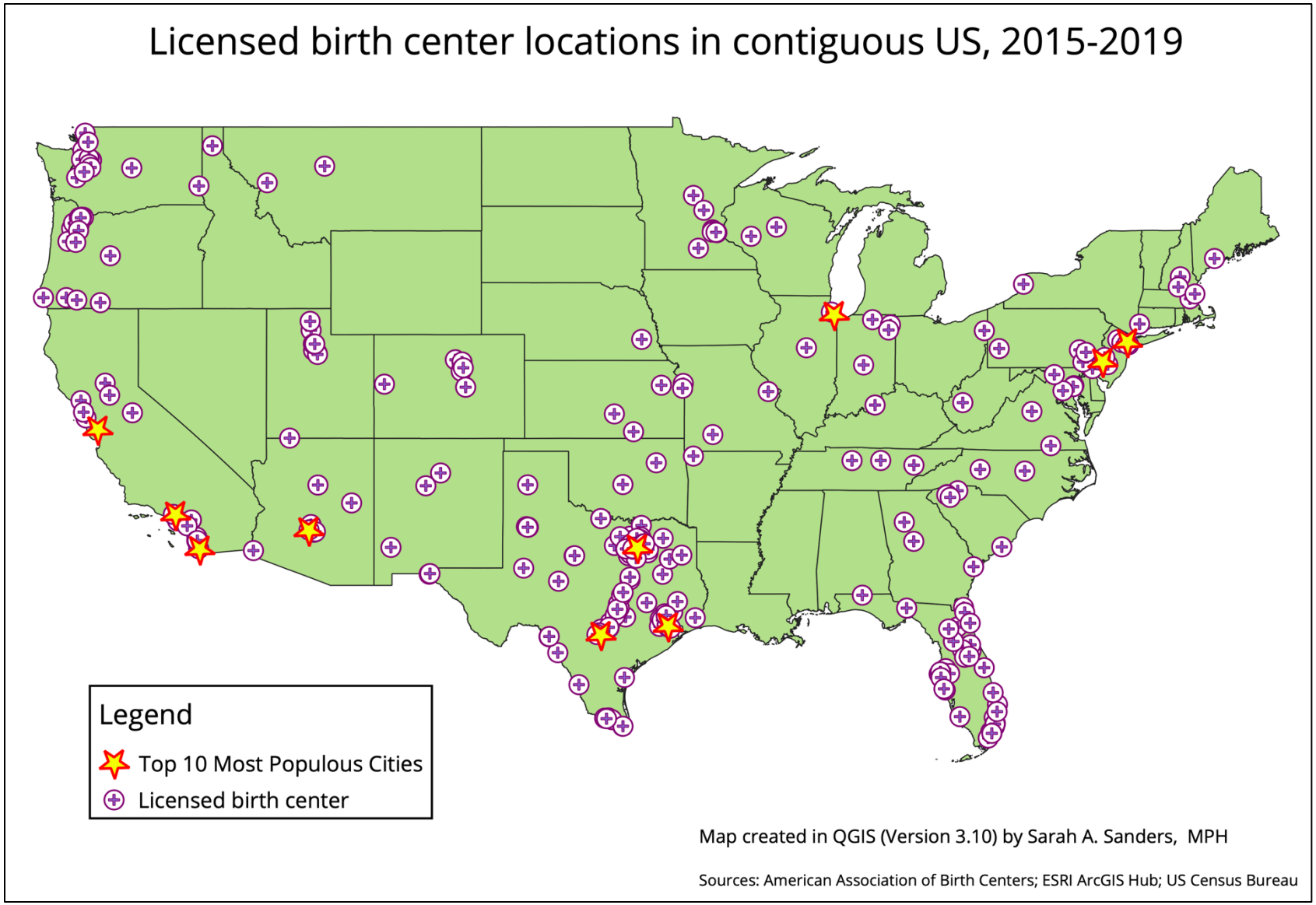

Figure 7. Map of licensed birth centers (n=271) in the contiguous US, overlaid with the top 10 most populous cities.

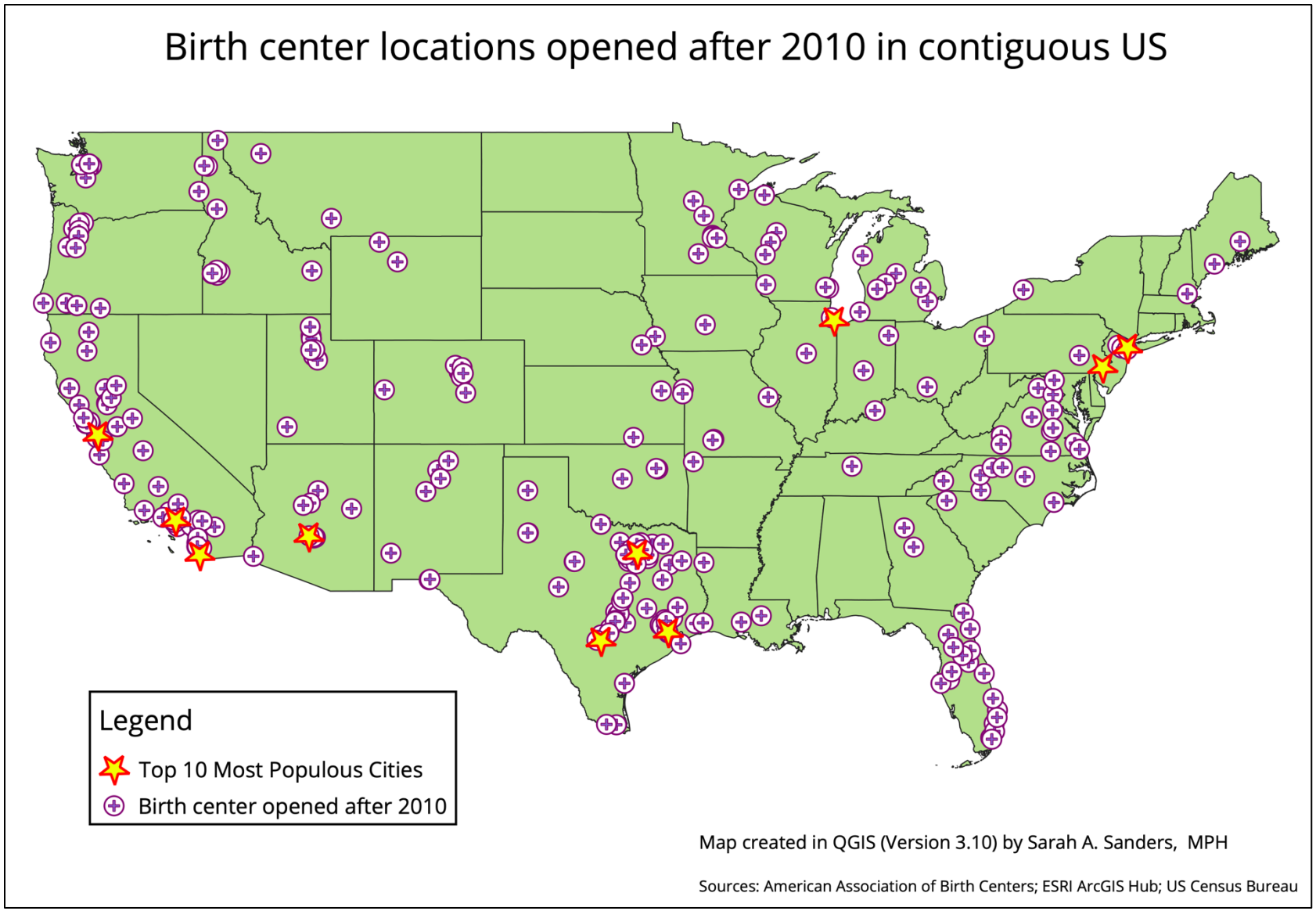

Figure 8. Map of birth centers opened after 2010 (n=276) in the contiguous US, overlaid with the top 10 most populous cities.

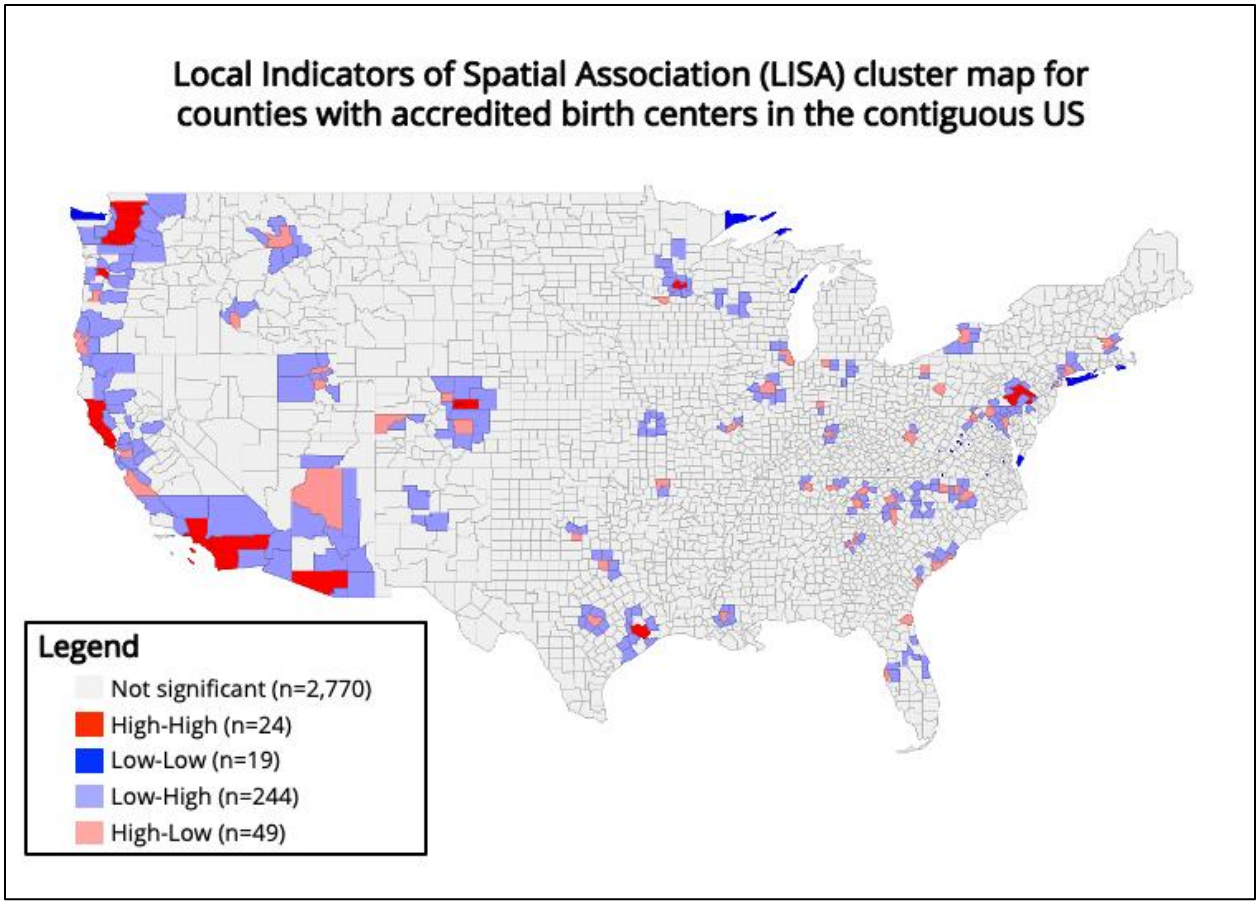

Figure 9. Cluster map of counties with at least one accredited birth center, based on local Moran's I testing.

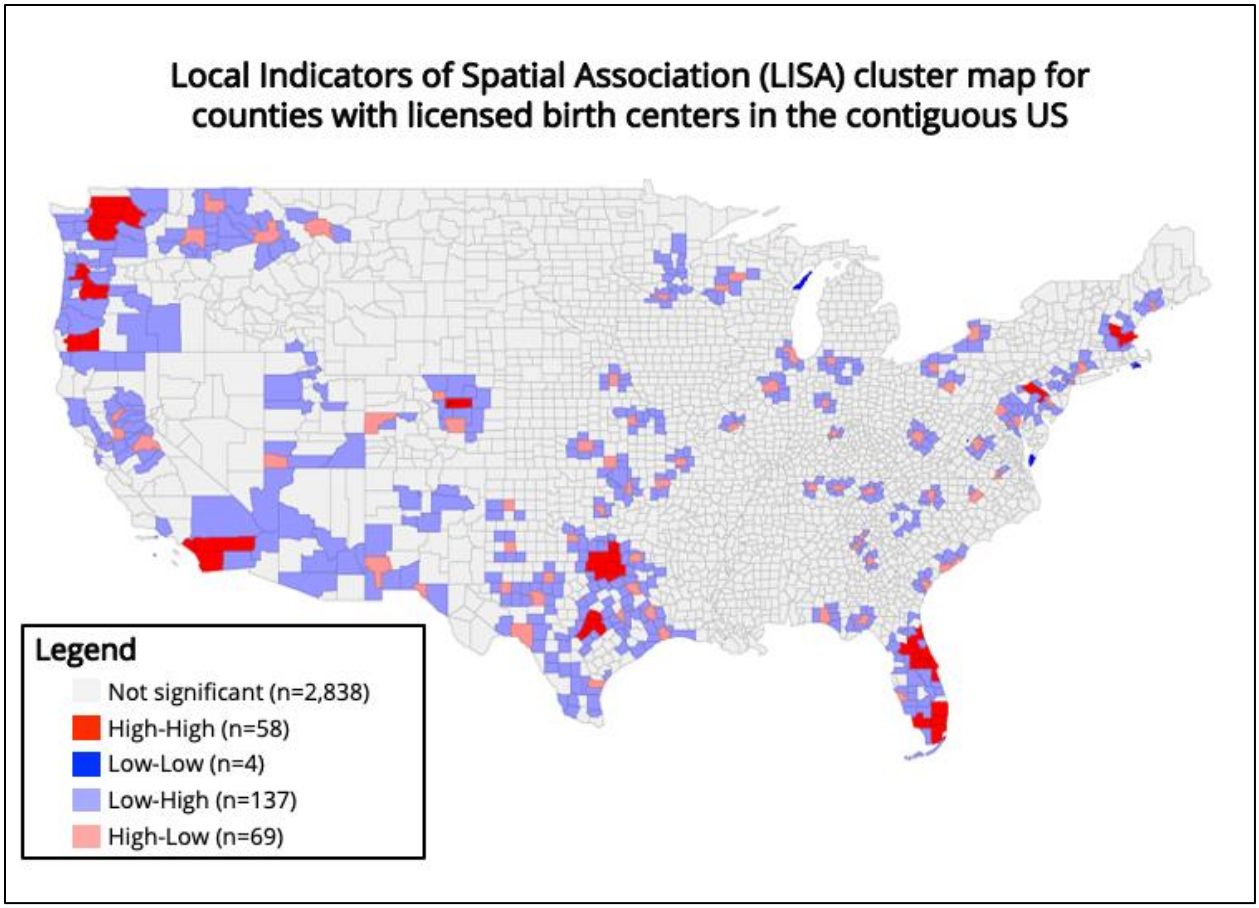

Figure 10. Cluster map of counties with at least one licensed birth center, based on local Moran's I testing.

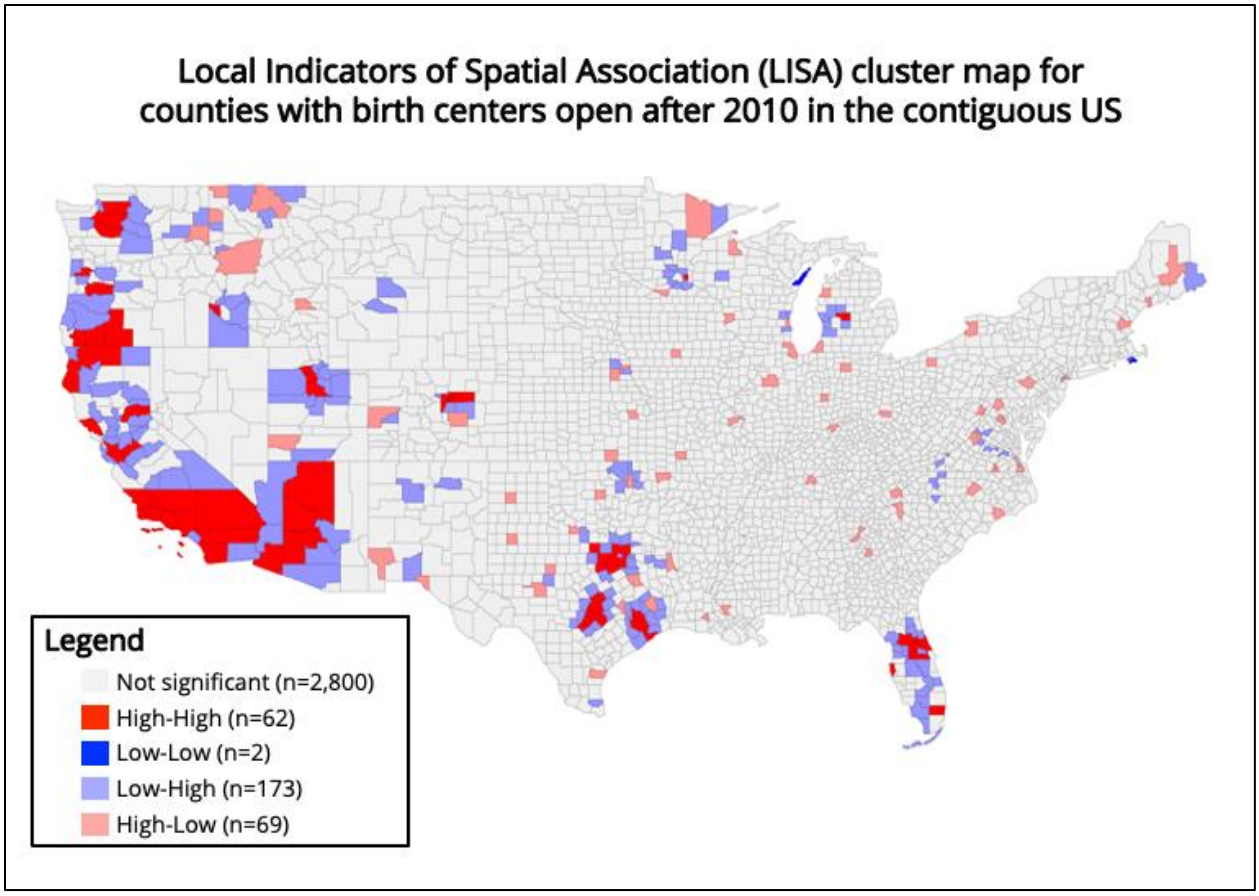

Figure 11. Cluster map of counties with at least one birth center opening after 2010, based on local Moran's I testing.

Appendix B – Paper 2

Table 13. State-level variables extracted from the MISS (Midwifery Integration Scoring System)[38] for the contiguous United States (48 states and Washington, DC).

Variable	Type	Definition & Values
Midwifery integration score	Continuous	Composite summary scores from 50-item scale; integer values range from 0-50, with 50 representing the highest level of midwifery integration
Provides birth center services	Binary	Confirmation that midwives with the indicated credentials serve as providers at birth centers (1=yes)
State regulation	Categorical	Confirmation that midwives with the indicated credentials can achieve licensure through the state; values include "prohibited", "allowed/not regulated", and "licensed"
Midwife required on board or council	Binary	Confirmation that representation of the indicated credential is required by the state's regulatory board, council, or advisory group (1=yes)
VBAC allowance	Categorical	Legality for licensed midwives to attend VBACs (vaginal birth after cesarean); values include "prohibited/unregulated", "allowed only by restrictive conditions", "allowed by meeting certain conditions", and "unrestricted"
Collaborative agreement required	Binary	Confirmation that licensed midwives are required to establish a consultation agreement or collaborative practice agreement with a physician (1=yes)
Statutory limitations	Binary	Confirmation that licensed midwives may face statutory limitations to site of practice, including lack of access to hospital privileging (1=yes)
Medicaid reimbursement	Binary	Confirmation that licensed midwives are entitled to reimbursement from state Medicaid programs (1=yes)
Scope limited to childbearing year	Binary	Confirmation that licensed midwives are limited to practicing during the childbearing year and not beyond (1=yes)
Scope includes well-woman care	Binary	Confirmation that licensed midwives can provide reproductive health services, outside of pregnancy (1=yes)
Physician supervision required	Binary	Confirmation that physician supervision is required for licensed midwives (1=yes)
Prescriptive authority	Categorical	Degree of authority with which licensed midwives are able to prescribe needed medications to clients; values include "prohibited", "allowed only by physician prescription", "limited list of medications allowed", "comprehensive list of medications allowed", and "full prescription-writing authority"

Table 14. Variables from the MISS (Midwifery Integration Scoring System)[38] that were collapsed into fewer groups or as binary measures for descriptive and regression analyses.

Variable	Values in raw dataset	Recoded values
State regulation	Prohibited; allowed by previous judicial opinion/or not mentioned/not prosecuted to date; unregulated but allowed by statutory permission; licensed	Prohibited (0); allowed/not regulated (1); licensed (2)
Midwife required on board or council	No; credential not specified; yes	No/credential not specified (0); yes (1)
Collaborative agreement required	Yes, formal written agreement/or formal consultation required/or unregulated; yes, but informal and unwritten; no agreement required	No agreement required (0); yes, formal or informal agreement required (1)
Statutory limitations	Yes; lack of access to hospital privileging or physician consultation/referral/signer; no	No limitations (0); yes, including lack of access to hospital privileging or physician consultation (1)
Medicaid reimbursement	No; yes, but challenges being reimbursed; yes	No (0); yes, including with challenges (1)

Table 15. Univariable regression results for structural racism measures in relation to birth center presence in all counties in the contiguous US (N=3,108), including odds ratios and 95% confidence intervals.

	Odds Ratio [95% Confidence Interval]		
	All birth centers	**Accredited birth centers**	**Licensed birth centers**
IMR ratio[b]			
Quartile 1 (1.00-1.90)	REF	REF	REF
Quartile 2 (1.91-2.40)	0.71 [0.37-1.38]	1.74 [0.71-4.27]	0.85 [0.41-1.77]
Quartile 3 (2.41-3.10)	1.58 [0.85-2.95]	2.91 [1.24-6.80]	1.60 [0.81-3.15]
Quartile 4 (3.11-7.40)	0.69 [0.36-1.33]	1.55 [0.62-3.84]	0.95 [0.46-1.94]
LBW ratio[c]			
Quartile 1 (0.70-1.60)	REF	REF	REF
Quartile 2 (1.61-1.80)	1.54 [1.01-2.34]	2.35 [1.23-4.50]	1.71 [1.04-2.81]
Quartile 3 (1.81-2.10)	1.68 [1.12-2.55]	1.93 [0.99-3.77]	1.88 [0.15-3.07]
Quartile 4 (2.11-4.50)	1.06 [0.68-1.65]	1.21 [0.59-2.49]	0.98 [0.57-1.70]
Educational attainment ratio[d]			
Quartile 1 (0.81-9.00)	REF	REF	REF
Quartile 2 (0.51-0.80)	1.91 [1.38-2.63]	2.88 [1.67-4.99]	2.00 [1.35-2.97]
Quartile 3 (0.21-0.50)	1.17 [0.82-1.66]	1.65 [0.91-3.01]	1.31 [0.85-2.01]
Quartile 4 (0.00-0.20)	0.19 [0.10-0.34]	0.05 [0.01-0.41]	0.12 [0.05-0.31]
Employment ratio[e]			
Quartile 1 (1.01-2.90)	REF	REF	REF
Quartile 2 (0.91-1.00)	1.48 [1.09-2.01]	2.27 [1.35-3.80]	1.68 [1.16-2.45]
Quartile 3 (0.71-0.90)	0.67 [0.47-0.97]	1.01 [0.55-1.86]	0.76 [0.49-1.19]
Quartile 4 (0.00-0.70)	0.22 [0.13-0.37]	0.18 [0.06-0.53]	0.14 [0.06-0.31]
Income ratio[f]			
Quartile 1 (0.81-3.50)	REF	REF	REF
Quartile 2 (0.61-0.80)	1.28 [0.88-1.84]	1.91 [0.98-3.72]	1.67 [1.05-2.66]
Quartile 3 (0.51-0.60)	1.08 [0.72-1.62]	1.76 [0.86-3.60]	1.47 [0.89-2.43]
Quartile 4 (0.10-0.50)	0.72 [0.46-1.12]	1.84 [0.90-3.77]	0.90 [0.51-1.58]
Prisoner population ratio[g]			
Quartile 1 (0.00-2.70)	REF	REF	REF
Quartile 2 (2.71-4.10)	2.50 [1.39-4.50]	1.67 [0.40-7.02]	3.77 [1.78-8.02]
Quartile 3 (4.11-6.50]	4.95 [2.85-8.57]	11.83 [3.60-39.94]	6.62 [3.21-13.63]
Quartile 4 (6.51-131.00)	4.49 [2.58-7.82]	11.94 [3.63-39.28]	4.98 [2.38-10.40]
Index of dissimilarity[h]			
Quartile 1 (1.10-33.90)	REF	REF	REF
Quartile 2 (33.91-45.40)	6.56 [3.59-11.98]	11.96 [2.81-51.01]	10.11 [4.31-23.71]
Quartile 3 (45.41-56.70)	8.83 [4.88-15.99]	25.14 [6.07-104.13]	12.03 [5.16-28.03]
Quartile 4 (56.71-93.50)	6.05 [3.31-11.09]	13.06 [3.08-55.41]	7.90 [3.34-18.71]
Index of concentration at the extremes[i]			
Quartile 1 (0.91-1.00)	REF	REF	REF
Quartile 2 (0.81-0.90)	2.79 [1.60-4.86]	3.89 [1.08-14.01]	4.73 [1.78-12.56]
Quartile 3 (0.51-0.80)	6.37 [3.82-10.63]	15.88 [4.92-51.33]	16.27 [6.54-40.46]
Quartile 4 (-0.80-0.50)	6.88 [4.13-11.47]	14.45 [4.45-46.91]	16.53 [6.64-41.14]

[a]All structural racism measures represent variables recoded as categorical to represent each quartile of values; and comparisons of Black/African American and non-Hispanic White populations

[b]Infant mortality ratio is calculated for each county by dividing the Black infant mortality rate (infant deaths per 1,000 live births) by the non-Hispanic White infant mortality rate

[c]Low birthweight ratio is calculated for each county by dividing the Black low birthweight rate (percent of infants born below 2,500 grams) by the non-Hispanic White low birthweight rate

[d]Educational attainment ratio is calculated for each county by dividing the proportion of Black people over 25 years old with a bachelor's degree by the proportion of non-Hispanic White people over 25 with a bachelor's

[e]Employment ratio is calculated for each county by dividing the proportion of Black people over 16 years old with employment by the proportion of non-Hispanic White people over 16 with employment

[f]Income ratio is calculated for each county by dividing the median income for the Black populations by that for the non-Hispanic White populations

[g]Prisoner population ratio is calculated for each county by dividing the Black prisoner population proportion by the non-Hispanic White prisoner population proportion

[h]Index of Dissimilarity values are determined for each county by calculating the difference between the relative distribution of Black and non-Hispanic White population proportions across census tracts within that county

[i]Values for the Index of Concentration at the Extremes are determined for each county by summing the absolute differences between Black and non-Hispanic White population proportions, dividing census tract totals by county totals, and multiplying this sum by 0.5.

IMR: infant mortality rate; LBW: low birthweight rate

Table 16. Univariable regression results for midwifery scope variables in relation to birth center presence in all counties in the contiguous US (N=3,108), including odds ratios and 95% confidence intervals.

	Odds Ratio [95% Confidence Interval]		
	Presence of at least one BC	**Presence of at least one accredited BC**	**Presence of at least one licensed BC**
MW integration score (quartile)			
Quartile 1	REF	REF	REF
Quartile 2	0.73 [0.40-1.35]	1.36 [0.59-3.13]	1.19 [0.55-2.57]
Quartile 3	3.37 [2.07-5.49]	2.82 [1.32-6.05]	3.94 [2.02-7.68]
Quartile 4	6.57 [4.15-10.40]	4.40 [2.15-9.04]	8.18 [4.35-15.37]
CPM required on board			
Yes	2.15 [1.28-3.61]	0.84 [0.45-1.59]	1.89 [1.03-3.48]
VBAC allowance			
Prohibited/unregulated	REF	REF	REF
Allowed by restrictive conditions	3.48 [1.58-7.68]	2.08 [0.81-5.34]	1.67 [0.68-4.10]
Allowed by conditions	3.68 [1.76-7.67]	1.10 [0.45-2.65]	2.86 [1.30-6.29]
Unrestricted	2.41 [1.08-5.39]	1.23 [0.46-3.30]	1.39 [0.56-3.42]
CPM provides BC services			
Yes	3.61 [2.42-5.40]	1.34 [0.79-2.27]	3.11 [1.93-5.01]
Collaborative agreement required for CPM			
Yes	0.77 [0.57-1.02]	0.96 [0.60-1.53]	0.49 [0.34-0.71]
MA reimbursement for CPM			
Yes	2.48 [1.85-3.31]	2.14 [1.34-3.43]	1.77 [1.25-2.51]
CPM scope limited to childbearing year			
Yes	0.67 [0.48-0.95]	0.72 [0.41-1.24]	0.76 [0.50-1.15]
CPM scope includes well-woman care			
Yes	3.20 [2.23-4.58]	2.78 [1.61-4.81]	2.54 [1.66-3.89]
Physician supervision requirement for CPM			
Yes	0.38 [0.16-0.87]	1.08 [0.43-2.75]	0.51 [0.20-1.28]
CPM prescriptive authority			
Prohibited	REF	REF	REF
Physician only	2.00 [1.24-3.24]	0.81 [0.35-1.86]	4.39 [2.28-8.45]
Limited	2.15 [1.35-3.40]	2.11 [1.09-4.10]	2.77 [1.43-5.41]
Comprehensive	3.60 [2.27-5.71]	1.88 [0.92-3.85]	5.57 [2.90-10.68]

Note: all regression models exclude counties where CPM licensure is not available (n=1,649)
BC: birth center; CB: childbearing; CPM: Certified Professional Midwife; MA: Medicaid; VBAC: vaginal birth after cesarean

Table 17. Univariable regression results for overall and childbearing demographics in relation to birth center presence in all counties in the contiguous US (N=3,108), including odds ratios and 95% confidence intervals.

	Odds Ratio [95% Confidence Interval]		
	Presence of at least one BC	**Presence of at least one accredited BC**	**Presence of at least one licensed BC**
Black %	1.00 [0.99-1.01]	1.01 [0.99-1.02]	1.00 [0.99-1.01]
NHW %	0.98 [0.97-0.98]	0.98 [0.97-0.98]	0.97 [0.97-0.98]
Urbanity classification	0.50 [0.46-0.55]	0.39 [0.33-0.46]	0.46 [0.41-0.52]
Noncore (non-MSA)	REF	REF	REF
Micropolitan (MSA <50k)	3.67 [2.04-6.62]	4.15 [1.03-16.63]	13.40 [3.95-45.47]
Small metro (50-250k)	10.69 [6.12-18.70]	16.57 [4.70-58.49]	44.68 [13.62-146.61]
Medium metro (250k-1m)	18.02 [10.60-30.63]	30.33 [9.08-101.31]	59.03 [18.21-191.29]
Large fringe metro (>1m)	14.55 [8.59-24.96]	27.72 [8.25-93.16]	54.67 [16.82-177.64]
Large central metro (>1m)	109.08 [8.49-213.72]	365.30 [106.85-1248.88]	436.00 [127.62-1489.50]
Black CB %	1.00 [0.99-1.01]	1.01 [1.00-1.02]	1.00 [0.99-1.01]
NHW CB %	0.98 [0.97-0.98]	0.98 [0.97-0.98]	0.97 [0.97-0.98]
Non-native CB %	1.09 [1.08-1.11]	1.09 [1.07-1.11]	1.10 [1.08-1.11]
CB % receiving benefits in last year	0.94 [0.87-1.03]	0.94 [0.82-1.08]	0.92 [0.83-1.03]
CB % living below poverty level	0.94 [0.93-0.96]	0.92 [0.89-0.95]	0.95 [0.92-0.97]

BC: birth center; CB: childbearing; MSA: metropolitan statistical area; NHW: non-Hispanic White

Table 18. Correlation matrix of county-level variables describing overall demographics, childbearing demographics, and measures of structural racism in the contiguous US (see Variable Dictionary for variable abbreviations and definitions).

		Overall Demographics			Chidlbearing Demographics					Structural Racism Measures[a]							
		BLK	NHW	URB	CBB	CBW	NN	PUB	POV	EDU[b]	EMP[c]	INC[d]	IMR[e]	LBW[f]	PRI[g]	DIS[h]	ICE[i]
Overall Demographics	BLK																
	NHW	-0.62															
	URB	357.4***	206.1***														
Childbearing Demographics	CBB	0.99	-0.61	385.5***													
	CBW	-0.60	0.99	196.9***	-0.61												
	NN	-0.02	-0.48	415.4***	-0.02	-0.50											
	PUB	0.00	-0.06	40.8***	-0.00	-0.06	-0.08										
	POV	0.38	-0.36	332.5***	0.38	-0.34	-0.15	0.25									
Structural Racism Measures[a]	EDU[b]	868.4***	353.6***	-0.30	924.6***	320.4***	107.4***	1.7	46.1***								
	EMP[c]	556.1***	280.1***	-0.20	772.7***	326.1***	217.4***	15.1**	32.7***	0.33							
	INC[d]	229.7***	100.4***	-0.01	242.1***	100.2***	10.3*	2.1	79.9***	0.33	0.23						
	IMR[e]	9.8*	8.5*	-0.14	11.9**	8.7*	10.8*	18.4***	2.3	-0.43	-0.39	-0.42					
	LBW[f]	61.9***	24.1***	0.01	63.8***	24.8***	9.1*	9.3*	6.0	-0.15	-0.04	-0.16	0.05				
	PRI[g]	88.9***	55.9***	-0.36	86.4***	51.1***	67.8***	7.4	159.9***	0.03	0.11	-0.23	0.60	0.10			
	DIS[h]	487.0***	275.9***	-0.14	454.8***	245.7***	32.8***	76.9***	76.3***	-0.04	-0.12	-0.06	0.48	-0.05	0.34		
	ICE[i]	1603.0***	2817.3***	0.30	1469.2***	2620.6***	782.2***	9.4*	326.8***	-0.13	-0.20	0.26	0.18	-0.14	0.13	0.47	

[a]All structural racism measures represent variables recoded as categorical to represent each quartile of values; and comparisons of Black/African American and non-Hispanic White populations

[b]Educational attainment ratio is calculated for each county by dividing the proportion of Black people over 25 years old with a bachelor's degree by the proportion of non-Hispanic White people over 25 with a bachelor's

[c]Employment ratio is calculated for each county by dividing the proportion of Black people over 16 years old with employment by the proportion of non-Hispanic White people over 16 with employment

[d]Income ratio is calculated for each county by dividing the median income for the Black populations by that for the non-Hispanic White populations

[e]Infant mortality ratio is calculated for each county by dividing the Black infant mortality rate (infant deaths per 1,000 live births) by the non-Hispanic White infant mortality rate

[f]Low birthweight ratio is calculated for each county by dividing the Black low birthweight rate (percent of infants born below 2,500 grams) by the non-Hispanic White low birthweight rate

[g]Prisoner population ratio is calculated for each county by dividing the Black prisoner population proportion by the non-Hispanic White prisoner population proportion

[h]Index of Dissimilarity values are determined for each county by calculating the difference between the relative distribution of Black and non-Hispanic White population proportions across census tracts within that county

[i]Values for the Index of Concentration at the Extremes are determined for each county by summing the absolute differences between Black and non-Hispanic White population proportions, dividing census tract totals by county totals, and multiplying this sum by 0.5.

* $p<0.05$

** $p<0.01$

*** $p<0.001$

Table 19. Correlation matrix of county-level variables describing integration and CPM scope of care with county-level measures of overall demographics, childbearing demographics, and structural racism in the contiguous US (see Variable Dictionary for variable abbreviations and definitions).

		Integration and CPM Scope[a]										
		MWI[b]	BCS	BRQ	VBC	COL	LIM[c]	MA	CB	WW	PHY	RX
Integration and CPM Scope	MWI[b]											
	BCS	0.63										
	BRQ	0.45	0.66									
	VBC	0.48	0.51	0.37								
	COL	-0.70	-0.45	-0.10	-0.31							
	LIM[c]											
	MA	0.01	0.81	0.21	0.22	0.30						
	CB	-0.02	-0.56	-1.00	-0.45	0.01		-0.88				
	WW	0.07	0.48	1.00	-0.11	0.37		1.00	-0.00			
	PHY	-0.23	-1.00	1.00	-0.32	1.00		-1.00	1.00	-1.00		
	RX	0.70	0.38	0.38	0.11	-0.16		0.25	0.07	0.31	0.13	
Overall Demographics	BLK	320.6***	0.12	0.39	***	-0.38		-0.13	0.07	0.04	0.11	241.3***
	NHW	21.8***	0.21	-0.13	***	-0.10		0.15	-0.11	0.22	-0.22	110.3***
	URB	0.10	0.05	0.06	0.03	-0.16		-0.15	0.13	-0.09	-0.06	0.03
Childbearing Demographics	CBB	285.9***	0.11	0.39	***	-0.37		-0.13	0.06	0.04	0.11	186.4***
	CBW	27.4***	0.23	-0.12	***	-0.12		0.17	-0.12	0.23	-0.23	88.4***
	NN	134.9***	-0.20	-0.08	***	0.17		-0.17	0.09	-0.25	0.13	56.1***
	PUB	4.7	-0.05	-0.02	***	-0.04		-0.22	0.15	-0.16	0.11	45.7***
	POV	115.8***	0.07	0.09	***	-0.14		-0.04	-0.00	-0.07	0.07	38.6***
Structural Racism Measures[d]	EDU[e]	-0.03	-0.03	-0.02	0.00	0.06		0.13	-0.10	0.07	-0.03	0.01
	EMP[f]	-0.04	0.03	-0.05	0.01	-0.00		0.13	-0.08	0.05	-0.06	-0.03
	INC[g]	0.10	0.06	0.18	0.19	-0.01		0.15	-0.16	0.05	0.03	0.02
	IMR[h]	0.12	-0.04	0.12	0.10	-0.02		-0.08	0.01	0.11	0.13	0.28
	LBW[i]	-0.11	0.00	0.10	-0.07	0.13		-0.00	0.03	0.01	-0.08	-0.06
	PRI[j]	0.12	-0.11	-0.02	-0.07	0.06		-0.12	-0.05	-0.03	0.10	0.09
	DIS[k]	0.27	-0.11	0.10	-0.04	-0.17		-0.13	0.11	0.08	0.19	0.38
	ICE[l]	0.14	-0.14	0.23	0.17	-0.03		-0.19	0.13	-0.18	0.24	0.31

[a]Analyses including state-level variables are limited to counties where CPMs can be licensed
[b]Midwifery integration measure represents variable recoded as categorical to represent each quartile of values
[c]No analyses were conducted for this variable due to the lack of variation in values.
[d]All structural racism measures represent variables recoded as categorical to represent each quartile of values; and comparisons of Black/African American and non-Hispanic White populations
[e]Educational attainment ratio is calculated for each county by dividing the proportion of Black people over 25 years old with a bachelor's degree by the proportion of non-Hispanic White people over 25 with a bachelor's
[f]Employment ratio is calculated for each county by dividing the proportion of Black people over 16 years old with employment by the proportion of non-Hispanic White people over 16 with employment
[g]Income ratio is calculated for each county by dividing the median income for the Black populations by that for the non-Hispanic White populations
[h]Infant mortality ratio is calculated for each county by dividing the Black infant mortality rate (infant deaths per 1,000 live births) by the non-Hispanic White infant mortality rate
[i]Low birthweight ratio is calculated for each county by dividing the Black low birthweight rate (percent of infants born below 2,500 grams) by the non-Hispanic White low birthweight rate

[j]Prisoner population ratio is calculated for each county by dividing the Black prisoner population proportion by the non-Hispanic White prisoner population proportion

[k]Index of Dissimilarity values are determined for each county by calculating the difference between the relative distribution of Black and non-Hispanic White population proportions across census tracts within that county

[l]Values for the Index of Concentration at the Extremes are determined for each county by summing the absolute differences between Black and non-Hispanic White population proportions, dividing census tract totals by county totals, and multiplying this sum by 0.5.

* $p<0.05$

** $p<0.01$

*** $p<0.001$

Variable Dictionary

BCS – Birth center services offered by providers with CPM credentials

BLK – Overall Black population proportion

BRQ – State regulatory body required to have member with CPM credentials

CB – CPM scope limited to childbearing year

CBB – Black proportion of childbearing population

CBW – Non-Hispanic White proportion of childbearing population

COL – Collaborative agreement required for licensed CPMs

DIS – Index of Dissimilarity

EDU – Ratio of population 25 years or older with Bachelor's degree

EMP – Ratio of population 16 years or older with employment

ICE – Index of Concentration at the Extremes

IMR – Ratio of infant mortality rate (number of infant deaths per 1,000 live births)

INC – Ratio of median household income

LBW – Ratio of low birthweight rate (number of infants born below 2,500 grams per 1,000 live births)

LIM – Statutory limitations to site of practice for licensed CPMs

MA – Medicaid reimbursement available for licensed CPMs

MWI – Midwifery integration score

NHW – Overall Non-Hispanic White population proportion

NN – Foreign-born proportion of childbearing population

PHY – Physician supervision required for licensed CPMs

POV – Proportion of childbearing population living below 100% of the poverty level

PRI – Ratio of prisoner population

PUB – Proportion of childbearing population that received public assistance benefits in last year

RX – Prescriptive authority for licensed CPMs

URB – Urbanity designation

VBC – Allowance to attend VBACs (vaginal birth after cesarean) for licensed CPMs

WW – CPM scope includes well-woman care

Table 20. Association between county-level measures of structural racism and presence of an accredited birth center, adjusting for midwifery scope variables in logistic regression.

	Adjusted Odds Ratio [95% Confidence Interval]
Exposure Variables	**Final Model – Accredited birth center presence**
Index of Dissimilarity[a, b]	
Quartile 1 (1.10-33.90)	REF
Quartile 2 (33.91-45.40)	**6.75 [1.55-29.47]**
Quartile 3 (45.41-56.70)	**12.51 [2.93-53.39]**
Quartile 4 (56.71-93.50)	**7.59 [1.69-34.01]**
Index of Concentration at the Extremes[a, c]	
Quartile 1 (0.91-1.00)	REF
Quartile 2 (0.81-0.90)	**1.93 [1.07-3.50]**
Quartile 3 (0.51-0.80)	0.61 [0.26-1.46]
Quartile 4 (-0.80-0.50)	0.32 [0.07-1.43]
Covariates	
Urbanity classification	
Noncore (non-MSA)	REF
Micropolitan (MSA <50k)	1.66 [0.32-8.75]
Small metro (50-250k)	**6.37 [1.40-29.02]**
Medium metro (250k-1m)	**11.06 [2.55-48.04]**
Large fringe metro (>1m)	**10.63 [2.43-46.52]**
Large central metro (>1m)	**109.99 [23.33-518.48]**
Prescriptive authority for CPMs	
Prohibited	REF
Physician only	1.68 [0.76-3.71]
Limited	**3.37 [1.91-5.97]**
Comprehensive	**2.96 [1.54-5.69]**

[a]Structural racism measures represent variables recoded as categorical to represent each quartile of values; and comparisons of Black/African American and non-Hispanic White population
CB: childbearing; CPM: Certified Professional Midwife; MSA: metropolitan statistical area
[b]Index of Dissimilarity values are determined for each county by calculating the difference between the relative distribution of Black and non-Hispanic White population proportions across census tracts within that county
[c]Values for the Index of Concentration at the Extremes are determined for each county by summing the absolute differences between Black and non-Hispanic White population proportions, dividing census tract totals by county totals, and multiplying this sum by 0.5.

Table 21. Association between county-level measures of structural racism and presence of a licensed birth center, adjusting for midwifery scope variables in logistic regression.

	Adjusted Odds Ratio [95% Confidence Interval]
Exposure Variables	**Final Model – Licensed birth center presence**
Educational attainment ratio[a, b]	
Quartile 1 (0.81-9.00)	REF
Quartile 2 (0.51-0.80)	**1.76 [1.04-2.98]**
Quartile 3 (0.21-0.50)	1.63 [0.90-2.94]
Quartile 4 (0.00-0.20)	1.32 [0.38-4.57]
Employment ratio[a, c]	
Quartile 1 (1.01-2.90)	REF
Quartile 2 (0.91-1.00)	1.11 [0.68-1.84]
Quartile 3 (0.71-0.90)	0.63 [0.35-1.13]
Quartile 4 (0.00-0.70)	**0.26 [0.08-0.84]**
Index of Dissimilarity[a, d]	
Quartile 1 (1.10-33.90)	REF
Quartile 2 (33.91-45.40)	**6.47 [2.60-16.11]**
Quartile 3 (45.41-56.70)	**8.18 [3.22-20.76]**
Quartile 4 (56.71-93.50)	**8.17 [3.07-21.76]**
Index of Concentration at the Extremes[a, e]	
Quartile 1 (0.91-1.00)	REF
Quartile 2 (0.81-0.90)	1.36 [0.79-2.01]
Quartile 3 (0.51-0.80)	**0.49 [0.25-0.96]**
Quartile 4 (-0.80-0.50)	**0.19 [0.04-0.85]**
Covariates	
Urbanity classification	
Noncore (non-MSA)	REF
Micropolitan (MSA <50k)	**6.56 [1.45-29.73]**
Small metro (50-250k)	**25.40 [5.68-113.65]**
Medium metro (250k-1m)	**27.78 [6.26-123.17]**
Large fringe metro (>1m)	**33.96 [7.63-151.20]**
Large central metro (>1m)	**166.03 [33.73-817.19]**
Collaborative agreement required	
Yes	**0.35 [0.23-0.54]**
Medicaid reimbursement for CPMs	
Yes	**2.28 [1.25-4.18]**
Prescriptive authority for CPMs	
Prohibited	REF
Physician only	**9.27 [5.21-16.52]**
Limited	**2.33 [1.27-4.26]**
Comprehensive	**5.95 [2.98-11.88]**

[a]Structural racism measures represent variables recoded as categorical to represent each quartile of values; and comparisons of Black/African American and non-Hispanic White population

[b]Educational attainment ratio is calculated for each county by dividing the proportion of Black people over 25 years old with a bachelor's degree by the proportion of non-Hispanic White people over 25 with a bachelor's

[c]Employment ratio is calculated for each county by dividing the median income for the Black populations by that for the non-Hispanic White populations

[d]Index of Dissimilarity values are determined for each county by calculating the difference between the relative distribution of Black and non-Hispanic White population proportions across census tracts within that county

[e]Values for the Index of Concentration at the Extremes are determined for each county by summing the absolute differences between Black and non-Hispanic White population proportions, dividing census tract totals by county totals, and multiplying this sum by 0.5.

CB: childbearing; CPM: Certified Professional Midwife; MSA: metropolitan statistical area

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