

Labor and Delivery Unit Closures in Rural Georgia from 2012–2016 and the Impact on Black Women: A Mixed-Methods Investigation

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Abstract

Background. Obstetric provider coverage in rural Georgia has worsened, with nine rural labor and delivery units (LDUs) closing outside the Atlanta Metropolitan Statistical Area from 2012–2016. Georgia consistently has one of the highest maternal mortality rates in the nation and faces increased adverse health consequences from this decline in obstetric care.

Objective. This study explores what factors may be associated with rural hospital LDU closures in Georgia from 2012–2016.

Methods. This study describes differences between rural Georgia hospitals based on LDU closure status through a quantitative analysis of 2011 baseline regional, hospital, and patient data, and a qualitative analysis of newspaper articles addressing the closures.

Results. LDUs that closed had higher proportions of Black female residents in their Primary Care Service Areas (PCSAs), of Black birthing patients, and of patients with Medicaid, self-pay or other government insurance; lower LDU birth volume; more women giving birth within their PCSA of residence; fewer obstetricians and obstetric provider equivalents per LDU; and fewer average annual births per obstetric provider. Qualitative results indicate financial distress primarily contributed to closures, but also suggest that low birth volume and obstetric provider shortage impacted closures.

Conclusions for Practice. Rural LDU closure in Georgia has a disproportionate impact on Black and low-income women and may be prevented through funding maternity healthcare and addressing provider shortages.

Keywords: rural health, maternal health, obstetric shortage, maternal mortality, health disparities

Significance

What is already known about this subject

Contributors to rural LDU closure in certain United States (U.S.) states include financial distress, decline in birth volume, lack of obstetrical providers, and high regional unemployment.

What this study adds

This study identifies specific contributors to LDU closure in rural Georgia, a state with exceptionally high maternal and infant mortality. The mixed-method approach provides a comprehensive analysis of quantitative data combined with synthesis of relevant news articles. Factors associated with rural Georgia LDU closure include higher proportions of Black female residents of reproductive age, of Black birthing patients, and of patients with government medical insurance or self-pay; lower LDU birth volume; more women giving birth within their region of residence; fewer obstetricians and obstetric provider equivalents per LDU; and fewer average annual births per obstetric provider.

Introduction

National Obstetric Care Shortage

In 2014, approximately 15% of the United States' 4 million annual births occurred in rural hospitals (Hung, Casey, Kozhimannil, Karaca-Mandic, & Moscovice, 2018). From 2010–2012, 75% of rural women gave birth at a local hospital (Kozhimannil, Casey, Hung, Prasad, & Moscovice, 2016; Kozhimannil, Hung, Prasad, Casey, & Moscovice, 2014). Since 2003, adequate obstetric care coverage has declined in rural communities across the U.S. (Hung, Henning-Smith, Casey, & Kozhimannil, 2017; Hung, Kozhimannil, Casey, & Moscovice, 2016; Kozhimannil, Henning-Smith, Hung, Casey, & Prasad, 2016). 162 rural hospitals closed from 2005–2019, including 18 in 2019 alone (The Cecil G. Sheps Center for Health Services Research, 2020). As of 2019, 673 additional facilities — one-third of rural hospitals — were vulnerable to closure (Anderson et al., 2019). Many rural hospitals that remain open have discontinued obstetric services, leaving 54% of rural counties in the U.S. with no hospital obstetric services as of 2014 (American College of Obstetricians and Gynecologists, 2014; Hung et al., 2017). Factors identified with rural hospital closure include financial distress, decline in birth volume, lack of obstetrical providers, and high regional unemployment (Balasubramanian & Jones, 2016; Holmes, Kaufman, & Pink, 2017; Hung et al., 2017, 2016; Nelson, 2017; Shah, 2018; Tong et al., 2013).

LDU closures pose significant health risks to women and infants, particularly Black women who face 3.2 times the risk of maternal death and 2 times the risk of fetal death compared to white women (MacDorman & Gregory, 2015; Petersen et al., 2019). A 2019 systematic review of 14 studies suggests that declines in rural U.S. obstetric care are associated with poorer health outcomes (Myrick, 2019). For example, travel to intrapartum care increased by an average of 29 miles for residents that lost local LDUs from 2010–2014 (Hung et al., 2016). Women without access to nearby obstetric care may experience higher risks of preterm birth and infant mortality, lack of adequate prenatal care, and unplanned out-of-hospital birth (Hung et al., 2017; Kozhimannil, Hung, Henning-Smith, Casey, & Prasad, 2018). In rural Alabama, counties that lost obstetric services in 2005 saw a doubling of infant mortality within 8 years, compared to a decrease in infant deaths in counties retaining continuous service (Powell, Skinner, Lavender, Avery, & Leeper, 2018). Declining obstetric services threatens the more than 28 million women of reproductive age living in rural counties and may exacerbate health disparities for Black women (Hung et al., 2017; Kozhimannil, Henning-Smith, et al., 2016).

Obstetric Care Shortage in Georgia

Obstetric care shortage has been a longstanding problem for rural Georgia, heightened by the closure of nine LDUs in hospitals outside the Atlanta Metropolitan Statistical Area (AMSA) from 2012–2016. From 2011–2016, the proportion of PCSAs outside of the AMSA with no obstetric providers rose from 37% to 44% (Carson & Pinto, 2017; Spelke, Zertuche, & Rochat, 2016). During this same time period, PCSAs with no delivering family practitioners (FPs) rose from 89% to 91% and PCSAs without certified nurse midwives (CNMs) rose from 70% to 76% (Carson & Pinto, 2017; Spelke et al., 2016).

For many years, Georgia has ranked in the top 10 states with highest maternal and infant mortality (MacDorman & Gregory, 2015). Among all U.S. states, Georgia had the 6th highest infant mortality rate in 2018 (7.05 infant deaths per 1,000 live births) (National Center for Health Statistics, 2018) and the 2nd highest maternal mortality ratio in 2019 (66.3 maternal deaths from pregnancy-associated causes per 100,000 live births) (United Health Foundation, 2019). According to the Georgia Maternal Mortality Review Committee (2019), from 2012–2014 there were 26 pregnancy-related deaths for every 100,000 births, and 60% of the 101 deaths were preventable.

Mirroring national statistics, Black women in Georgia are 3.3 times more likely to die from pregnancy-related causes than white women (Georgia Maternal Mortality Review Committee, 2019). From 2015–2018, Georgia's preterm birth rate rose from 10.8% to 11.4%, and in 2019 the preterm birth rate among Black women was 45% higher than the rate among women of all other races (March of Dimes, 2019). As a result of this disparity, the March of Dimes (2019) lowered Georgia's preterm birth grade from a "C" in 2016 to an "F" in 2019 — compared to a national "C" ranking in 2019. LDU closures in Georgia have serious implications for the health of Georgians, particularly Black women and infants disproportionately impacted by health risks and closures.

Purpose

This project aims to answer the question: What factors may be associated with rural Georgia LDU closures from 2012–2016? To address this question, this paper (1) analyzes 2011 baseline quantitative regional, LDU, and patient data and (2) assesses qualitative sources including newspaper articles addressing rural LDU closures in Georgia published from 2012–2016. By identifying contributors to rural LDU closure, this study contextualizes obstetric service decline in rural Georgia and may guide further research and policy to both prevent and respond to LDU closures.

Methods

This study was designated exempt from review by the Emory University Institutional Review Board.

Dependent and Independent Variables

The primary dependent variable was rural Georgia LDU closure from 2012–2016. The explanatory independent variables (listed in Tables 1–3) were identified based on literature on rural

obstetric service closure. Data from 2011 was used for all independent variables to consistently compare baseline characteristics of LDUs before the closure events (Hung et al., 2016).

Study Population

The sample included “rural” PCSAs containing, in 2011, (1) only counties outside of the AMSA, (2) only counties of population strictly less than 50,000, and (3) exactly one LDU (Health Resources & Services Administration, 2020). See Supplemental Table S1 for a complete list of rural PCSAs in sample. Under this frame, six of the nine LDUs outside the AMSA that closed from 2012–2016 were included in the sample. LDU data included all births within the hospital, whereas patient data included only births to Georgia residents within the hospital. For distance analysis of neighboring LDUs and urban areas, all Georgia hospitals with LDUs that had at least one birth in 2011 (including hospitals outside the rural sampling frame) were considered, and urban areas with population at least 50,000 (including urban areas in neighboring states) were identified.

Data Sources

Regional population and birth volume data was sourced from the Georgia Department of Public Health (2021) Online Analytical Statistical Information System (OASIS). Regional household income data was sourced from the United States Census Bureau (2011). The mapping of PCSAs to counties was obtained from the Georgia Board of Health Care Workforce (2008) and the counties belonging to the AMSA were identified by the Office of Management and Budget (2013). Provider and LDU information was collected by the Georgia Maternal and Infant Health Research Group (GMIHRG) in 2012. Patient data was obtained via Emory’s MCH Linked Vital Records Data Repository. Urban areas were identified using the 2010 criteria from the United States Census Bureau (2021). All Georgia LDUs and urban areas were located and plotted in Google My Maps.

Variable Measures

Regional-Level Measures: The 30 rural PCSAs comprised 41 counties. PCSA-level numerical variables were calculated as sums of county data, while average values were determined based on 2011 population-weighted proportions.

Distance Analysis: For each LDU, the nearest other Georgia LDU and nearest urban area were determined using Google My Maps and the shortest driving mileages were recorded.

Payor Group: Patient insurance types were split into two groups to conduct odds ratios. The “Assistance” group included Medicaid, Self-pay, and Other Government (Govt.) insurance plans; the “Commercial/Employer-Based” group included Commercial and Champus insurance plans.

OB Equivalents: The number of obstetric provider equivalents per LDU is calculated using the expected delivery load of obstetricians (OBs), CNMs, and FPs (Spelke et al., 2016):

$$\text{OB Equivalents} = \#OBs + \frac{1}{1.55} \cdot \#CNMs + \frac{0.70}{1.55} \cdot \#FPs$$

Average Annual Births Per Provider: This variable is calculated per LDU as birth volume divided by OB equivalents.

Quantitative Data Analysis

Data was analyzed using the Pandas package for Python (The Pandas Development Team, 2021) and the online OpenEpi calculator (Dean, Sullivan, & Soe, 2013). Most analyses used LDUs or their corresponding PCSAs as the unit of observation, comparing median values by LDU closure status. Median values were assessed for statistical significance with the exact Mann–Whitney U test appropriate for small-sample distributions (H. B. Mann & Whitney, 1947), reporting $p < .05$ as significant. Odds ratios and 95% confidence intervals were calculated at the patient level instead of at the LDU level to garner adequate statistical power to assess population-level associations between variables of interest and LDU closures. The association between Black/white race and LDU closure status was adjusted by payor group using the Cochran–Mantel–Haentzel method.

Qualitative News Assessment

Sampling Frame

The sample included newspaper articles and Georgia OBGYN Society reports published from 2011–2016 featuring LDU closures in Georgia. The Emory Newspaper Database (EBSCO) and Google Scholar were used to search for newspaper articles including the following keywords: “Georgia”, “labor and delivery unit closure”, “rural”, “obstetric services”, and “stops delivering babies”. 18 news articles were identified for qualitative analysis: 17 published by Georgia sources and one published by a national source.

Data Analysis

Content and thematic analysis were used to analyze newspaper articles. A codebook was developed with key themes derived from the data, and articles were coded to identify these themes. Results of thematic analysis were presented through in-depth thematic descriptions grounded in the data and illustrated through exemplar quotes.

Results

Across the state of Georgia, infants were delivered at 88 hospitals with LDUs in 2011, 30 of which were identified in this study as rural. From 2012–2016, 24 rural hospitals retained LDU services while six rural hospitals discontinued them. One rural LDU closed in 2012, two closed in 2013, two closed in 2014, and one closed in 2015. Four of the six rural LDUs that closed were in southeastern Georgia.

This study determined that significant quantitative factors correlated with LDU closure included regional demographics, patient race and payor group, LDU birth volume, location of delivery, numbers of LDU OBs and OB equivalents, and average annual births per provider. Factors that were not found to correlate with LDU closure included PCSA total population, PCSA population of females of reproductive age, PCSA median household income, LDU distances to nearest neighboring LDUs and urban areas, numbers of CNMs and FPs per LDU, and average OB age.

Patient Race and Payor Group

Black women made up a higher proportion of both patients of LDUs that closed and residents of PCSAs where the LDU closed. At the population level, the racial demographics of women of reproductive age (15–44 years) differed significantly based on LDU closure region. The odds of having a Black female resident of reproductive age were 7% higher for PCSAs containing LDUs that subsequently closed compared to PCSAs with LDUs that remained open (OR 1.07, 95% CI 1.04–1.10). Although not a statistically significant difference, Black women accounted for a median value of 41.92% of patients who delivered at LDUs that closed, but a median value of only 34.45% of women of reproductive age living in a PCSA where the LDU closed (Figure 1). Among patients of Black and white race with known payor group, LDUs that eventually closed had 46% higher odds of having a Black birthing patient than LDUs that remained open (OR 1.46, 95% CI 1.26–1.68). Controlling for payor group, LDUs that eventually closed had 34% higher odds of having a Black birthing patient than LDUs that remained open (AOR 1.34, 95% CI 1.16–1.55).

Distribution of payor type differed based on LDU closure status. The median proportion of patients with commercial or employer-based insurance was lower for LDUs that closed (5.26%) than for LDUs that remained open (10.8%, $p = .16$) (Table 1). Among patients with a known payor group, the odds of a birthing patient having a form of “Assistance” insurance (Medicaid, Self-pay, or Other Govt.) was 75% higher for LDUs that subsequently closed compared to those that remained open (OR 1.75, 95% CI 1.41–2.17).

Qualitative Results: Patient Payor Group

Many news sources from 2013–2016 attributed LDU closures to costly obstetric services receiving inadequate reimbursement. In 2014, Emmanuel Hospital lost \$700,000 from its birthing unit (Ethridge, 2015). Medicaid — which covered 60% of Georgia births statewide and up to 85% of births in some counties — paid approximately one-third the amount private insurance reimbursed per birth. Despite Georgia OBs receiving the first Medicaid pay increase in 14 years in 2016, the increase did not reimburse hospital fees. A 2011 article projected that Medicaid expansion under the Affordable Care Act (ACA) would cover hundreds of thousands more Georgia residents (Miller, 2011). Policy advocates and healthcare providers were reported to encourage expanding Medicaid under the ACA, but opposition claimed that Georgia could not afford it (Miller, 2015). Four years later, several 2015 articles reported that not only had Georgia rejected Medicaid expansion, but the ACA cut indigent care funding to rural hospitals. As a result, rural hospitals were reported to reevaluate services that lose money.

“Small-town hospitals face a financial challenge in keeping birth centers open, hospital executives say.” (Anderson, 2015)

Birth Volume and Location of Delivery

Birth volume differed both by PCSA and by LDU. In 2011, regional median birth volume was observably lower for PCSAs with LDUs that closed (313) compared to PCSAs with LDUs that remained open (365, $p = .49$) (Figure 2, Table 2). Similarly, the median birth volume per LDU was significantly lower for LDUs that eventually closed (197) compared to those that remained open (435.5, $p = .003$). The nearest birth hospitals to LDUs that closed had higher median birth

volumes (773.5) than the nearest birth hospitals to LDUs that remained open (327), but not at a statistically significant level ($p = .06$).

The odds of a birthing patient living within the same PCSA as the LDU where she gave birth was 46% higher for LDUs that eventually closed than for LDUs that remained open (OR 1.46, 95% CI 1.28–1.66). Likewise, a higher median proportion of women gave birth in their county of residence at LDUs that closed (66.14%) compared to LDUs that remained open (55.2%, $p = .09$) (Table 2).

Qualitative Results: Birth Volume

Beginning in articles published in 2015, low birth volume became more frequently cited as a reason for LDU closure, usually in conjunction with financial issues. Experts reported a hospital needing a minimum of 350–500 births per year to financially break even (Miller, 2013a, 2015). Several sources indicated that rural women opting out of their local LDU contributed to low LDU birth volume, attributing this trend to affluent women with transportation choosing to deliver in more populous nearby counties. One article identified that hospitals providing services such as Level III Neonatal Intensive Care Units (NICUs), midwifery care, birth classes, and private birthing suites have succeeded in attracting birthing patients from surrounding regions (Dunkin, 2015). By contrast, LDUs which eventually closed experienced a loss of local patients. For example, in 2014, 360 infants were born to Emmanuel County residents, but only 120 were delivered at Emmanuel Hospital (Anderson, 2015).

“About two-thirds of [Emmanuel County] births have been delivered out of the county in larger neighboring hospitals. ‘As a result, the small number of deliveries at Emmanuel Medical Center is not sustainable,’ the hospital said in a news release.” (Miller, 2015)

Obstetric Providers

LDUs that closed had significantly fewer OBs, OB equivalents, and average annual births per provider. Across all rural LDUs, there were a total of 79 OBs, 15 CNMs and 11 FPs (Table 3). LDUs that closed had a median number of OBs compared to three at those that stayed open ($p = .04$). Similarly, LDUs that closed had a median number of two OB equivalents while those that remained open had three ($p = .04$). The median average annual births per provider was 108.25 among LDUs that closed compared to 133.64 among those that stayed open ($p = .03$) (Figure 2).

Qualitative Results: Obstetric Providers

As early as July 2011, newspapers featured accounts of Georgia OBs leaving rural practices due to financial difficulties. An article entitled “A doctor who couldn’t afford to stay in Ga.” suggested that if Georgia accepted healthcare reform, the state may have the opportunity to increase Medicaid reimbursement and keep OBs in rural practices (Miller, 2011). In 2013, a news article indicated that rural hospitals struggled to develop the economic quality of life necessary to recruit doctors to the community (Miller, 2013b). Along these lines, GMIHRG’s 2014 front page issue provided detailed information about the challenges obstetric providers faced, including prohibitive expenses, insufficient reimbursement, high liability costs, predominantly vulnerable and high-risk

population, and poor collaboration (Spelke, Julian, Pinto, & Zertuche, 2014). Furthermore, reasons for the decline in providers included aging of the OB workforce, decline of expected work hours, and early retiring of physicians.

“The OB-GYN workforce is aging, the average number of work hours is declining, and a large number of OB-GYNS are retiring from obstetrics early or not practicing obstetrics altogether because of high malpractice premiums.” (Anderson, 2015)

Discussion

Georgia’s trend in rural LDU closures is influenced by regional demographics and patterns of care-seeking, but primarily stems from rural economic distress observed across the country (Balasubramanian & Jones, 2016; Holmes et al., 2017). The results of this study confirm national trends in hospital closure related primarily to birth volume and financial difficulty (Holmes et al., 2017; Hung et al., 2017, 2016; Kozhimannil, Henning-Smith, et al., 2016; Kozhimannil et al., 2018).

LDUs that closed had a higher proportion of birthing patients that lived within the LDU’s PCSA, indicating they did not receive the influx of patients from neighboring regions like LDUs that remained open. These results were corroborated by several news articles that stated many rural Georgia residents opted out of delivering in their closest LDU, and mirror trends identified by Hung et al. (2016) that higher neighboring hospital birth volume may indicate local competition in obstetric service provision. Further research into patients’ care-seeking behavior and the impact of neighbor “competing” hospitals may better explain trends in travel, neighboring hospital birth volume, and patient racial make-up.

A comparison of racial demographics controlling for payor group indicates that while the odds of having a Black female resident of reproductive age were 7% higher for regions where the LDU closed, the odds of having a Black birthing patient was 34% higher for LDUs that closed. This discrepancy between service utilization and the underlying demographics suggests that Black women may have been more reliant on LDUs that closed, or were less able to access care in the ones that remained open. Overall, this finding indicates that Black women may be disproportionately impacted by rural LDU closure.

Significant difference in payor group builds on previous studies, with LDUs that closed having 75% higher odds of patients on Medicaid or self-pay insurance than those that remained open (Hung et al., 2017, 2016; Kozhimannil, Henning-Smith, et al., 2016; Kozhimannil et al., 2018). In 2010, 30.4% of Black Americans were covered by Medicaid compared to 14.5% of white Americans (Centers for Disease Control and Prevention, 2017). As of 2016, these figures rose to 33.8% and 18.7% respectively, indicating higher reliance on Medicaid coverage for patients overall (Centers for Disease Control and Prevention, 2017). These trends were overwhelmingly confirmed by the news articles, the majority of which highlighted that financial issues caused LDU closures.

Provider data demonstrated a correlation between LDU closure and having fewer OBs, OB equivalents, and average annual births per provider. Qualitative data describing the decreasing obstetric workforce reinforced previous findings that obstetric providers in Georgia faced significant financial barriers in service delivery and high cost of medical malpractice insurance (Pinto, Rochat, Hennink, Zertuche, & Spelke, 2016). Articles analyzed in this study suggest that OBs leaving rural

practice may present a warning sign for LDU closures. Ultimately, from 2012–2016, news sources in Georgia reported that LDU closures stemmed from economic difficulties, will likely continue to occur without serious interventions, and present severe threats to the health of rural women.

Implications

Black women and women using Medicaid and self-pay disproportionately face greater health risks and lack adequate access to perinatal healthcare (Holmes et al., 2017; Kozhimannil, Hung, Casey, & Lorch, 2016). Non-Hispanic Black women have higher odds of maternal mortality, fetal mortality, and maternal morbidities such as severe postpartum hemorrhage and peripartum infection than non-Hispanic white women, regardless of hospital type for delivery (Grobman et al., 2015; MacDorman & Gregory, 2015; Petersen et al., 2019). Hospital low birth volume poses higher risk of birth complications, such as 31% increased odds of post-partum hemorrhage, due to challenges in maintaining appropriate equipment and staff competencies (Kozhimannil, Thao, et al., 2016; S. Mann, McKay, & Brown, 2017). The acceleration of rural hospital closure may worsen care provision and health inequities for these populations. Effective solutions will need to disrupt the cycle of rural LDU closures stemming from low birth volume, inadequate financial reimbursement, competing neighboring hospitals, and low OB retention.

Results from the qualitative data suggest increasing funding to rural hospitals, incentivizing obstetric care providers to serve rural communities, and developing new models of maternity care as mechanisms to preserve rural LDUs. The Georgia Maternal Mortality Review Committee (2019) recommended increasing physicians accepting Medicaid, providing transport to doctors' visits, and detecting high-risk complications early. State Medicaid programs — which fund more than one-half of rural births — can improve access to care by increasing reimbursement benefits, managing transfer of care arrangements, addressing provider supply, and reporting quality care metrics for rural residents (Kozhimannil, Henning-Smith, et al., 2016). Healthcare systems can develop a “Maternal Health Compact” that links lower-level care hospitals with tertiary-care hospitals through transportation for critical cases and telehealth services for advanced care, training, and referral (Hung et al., 2017; S. Mann et al., 2017). States can improve obstetric shortages through expanding licensing and scope of practice for providers such as midwives, recruiting providers through training rotations and reimbursement, and integrating care collaborations between birth settings (Kozhimannil, Henning-Smith, et al., 2016). Lastly, community midwives can provide high levels of care competency for low-risk patients, achieving the same quality care outcomes in rural and non-rural settings (Hung et al., 2017; Nethery, Gordon, Bovbjerg, & Cheyney, 2018).

To address the high rates of maternal mortality and morbidity among Black women, legislators and healthcare systems should consider increasing political and financial priority for sustaining rural Georgia hospitals and LDUs. In 2018, the Georgia General Assembly provided \$2,000,000 to implement quality improvement projects in rural birthing hospitals and passed legislation to designate hospitals with maternal and neonatal levels of care (Georgia Maternal Mortality Review Committee, 2019). Impact evaluations of these efforts should focus on healthcare provision to Black women and women on Medicaid in rural communities. To combat Georgia's high rates of pregnancy-associated mortality, maternal morbidity, and preterm birth for all residents, attention must be given to preventing future closures and meeting the healthcare needs of individuals most affected by the decline in obstetric services.

Study Strengths & Limitations

This study provides a robust descriptive analysis of rural LDU closures in Georgia. Qualitative analysis of news articles contextualize quantitative data by providing specific examples of conditions impacting LDU closures. Limitations of this study include the small sample size of six closed LDUs, incomplete (“Other/Unknown”) data for patient race (12.0%) and payor status (15.7%), and lack of data for assessing associations between maternal levels of care and LDU closure.

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Declarations

Conflicts of Interest/Competing Interests

The authors declare that they have no conflicts of interest.

Ethics Approval

This study was designated exempt from review by the Emory University Institutional Review Board.

Availability of Data and Material

Data regarding regional population, birth volume, and household income; the mapping of PC-SAs to counties; the list of counties belonging to the AMSA; and the criteria for identifying urban areas were obtained from public sources as specified in *Data Sources*. Private data sources include the provider and LDU information collected by GMIHRG and the patient data obtained via Emory’s MCH Linked Vital Records Data Repository. All Georgia LDUs and urban areas were plotted in Google My Maps, available online at https://www.google.com/maps/d/u/3/edit?mid=1_xMZrJgPbcInCcq8CgdmwuncWMWSOoJj&usp=sharing.

Code Availability

Quantitative data was analyzed using the `pandas` package for python and OpenEpi software. All code for performing quantitative analysis is contained in a Jupyter notebook that is openly available at <https://github.com/aecdaymude/GeorgiaLDUClosure>.

Author Contributions

A.E.C. Daymude and R. Rochat conceived and designed the analysis, A.E.C. Daymude and J.J. Daymude collected the data and performed the analysis, J.J. Daymude developed analysis code, and A.E.C. Daymude wrote the manuscript in consultation with R. Rochat.

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Table 1: Race and Payor Group by LDU Closure Status (2011)

Variable	Total	LDUs that Stayed Open median (min–max)	LDUs that Closed median (min–max)	<i>p</i>
<i>PCSA Data</i>				
Total population	935,890	26,827 (9,679–61,530)	23,036 (17,125–31,086)	.25
Females 15–44 years old	178,044	5,054 (1,646–12,226)	4,398 (3,281–6,405)	.30
→ % Black	53,820	30.16% (0.88–53.83%)	34.45% (1.53–54.65%)	.60
→ % White	119,237	67.42% (42.78–97.05%)	63.44% (43.49–95.71%)	.67
→ % Other race	4,987	2.58% (1.71–4.47%)	2.10% (1.65–2.76%)	.03*
Median household income	—	\$34,249 (\$31,123–43,146)	\$33,589 (\$30,427–43,704)	.63
<i>Patient Data by LDU</i>				
% Black	4,101	31.85% (0.39–66.67%)	41.92% (1.46–72.49%)	.49
% White	6,713	56.04% (22.18–94.83%)	40.29% (25.40–95.12%)	.49
% Other/unknown race ^a	1,478	9.44% (3.07–45.11%)	3.84% (2.12–27.19%)	.17
% Commercial or employer-based insurance ^b	1,751	10.80% (0.20–30.51%)	5.26% (3.29–25.37%)	.16
% Medicaid insurance	7,390	71.44% (5.50–91.89%)	62.94% (29.27–94.55%)	.78
% Self-pay	921	4.45% (0–39.85%)	4.34% (0–26.50%)	.98
% Other govt. insurance	578	0.34% (0–62.07%)	0.43% (0–2.56%)	.78
% Other/unknown insurance	1,652	1.38% (0–86.53%)	11.42% (0–43.42%)	.53

* $p < .05$ ^a Includes American Indian, Asian, Multiracial, Native Hawaiian or Other Pacific Islander, and Unknown.^b Includes Commercial and Champus insurance plans.

Table 2: Birth Volume and Location by LDU Closure Status (2011)

Variable <i>(by PCSA/LDU)</i>	LDUs that Stayed Open <i>median (min–max)</i>	LDUs that Closed <i>median (min–max)</i>	<i>p</i>
PCSA birth volume	365 (101–776)	313 (213–361)	.49
LDU birth volume	435.5 (111–1,105)	197 (110–274)	.003*
Birth volume of nearest Georgia LDU	327 (110–2,569)	773.5 (118–3,454)	.06
Distance to nearest Georgia LDU (miles)	24.5 (7–34)	25 (19–32)	.60
Distance to nearest urban area (miles)	41.5 (26–64)	41.5 (21–69)	.74
% LDU patients who gave birth in their county of residence	55.20% (6.52–89.72%)	66.14% (48.72–88.18%)	.09

* $p < .05$

Table 3: Obstetric Providers by LDU Closure Status (2011)

Variable (by LDU)	Total	LDUs that Stayed Open <i>median (min–max)</i>	LDUs that Closed <i>median (min–max)</i>	<i>p</i>
Average annual births per provider	—	133.64 (55.5–233)	108.25 (55–144)	.03*
OB equivalents	93.65	3 (1–7.94)	2 (1.65–2.10)	.04*
OBs	79	3 (0–6)	1.5 (1–2)	.04*
CNMs	15	0 (0–4)	0 (0–1)	.94
FPs	11	0 (0–4)	0 (0–2)	.53
Average OB age (years)	—	46 (40–59.5)	48 (45–60)	.31

* $p < .05$

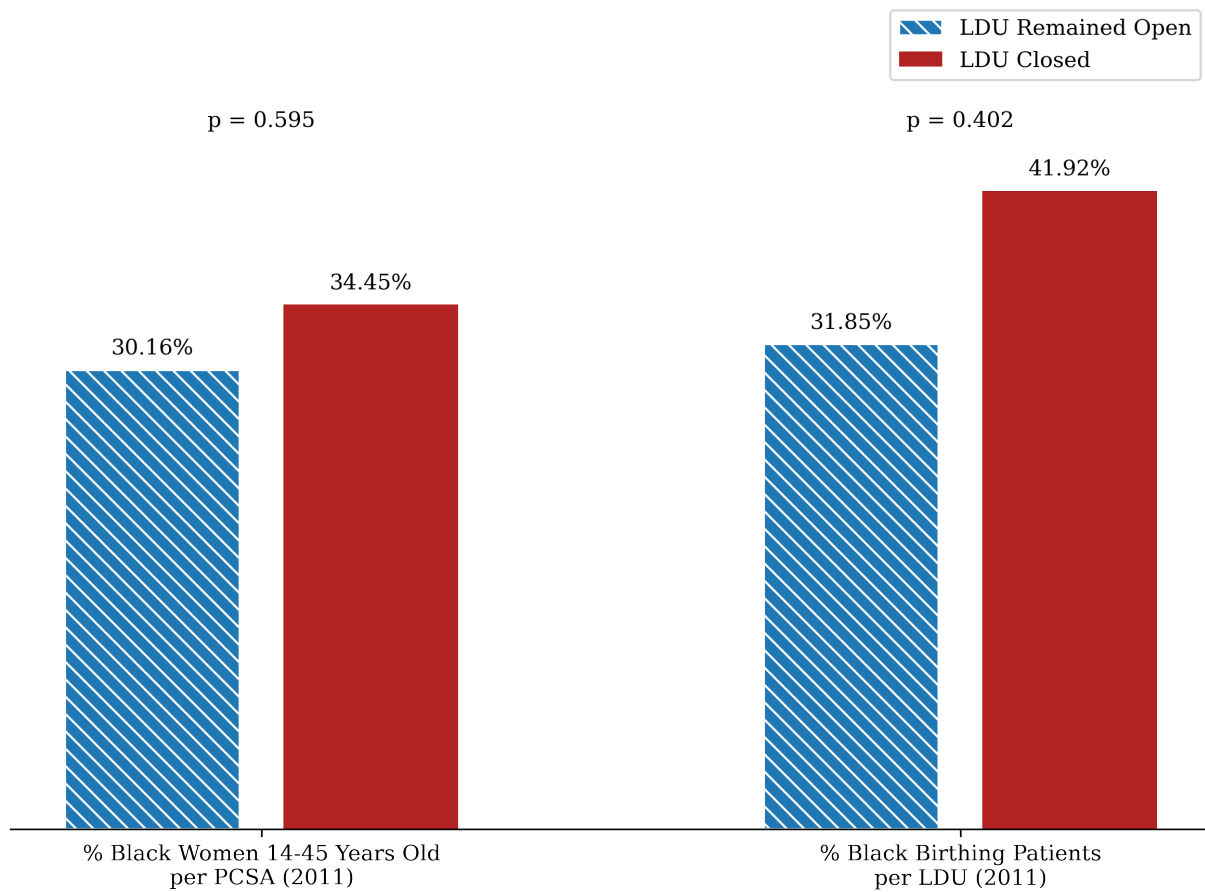


Figure 1: Median proportions of Black women of reproductive age per PCSA (2011) and of Black birthing patients per LDU (2011) by LDU closure status.

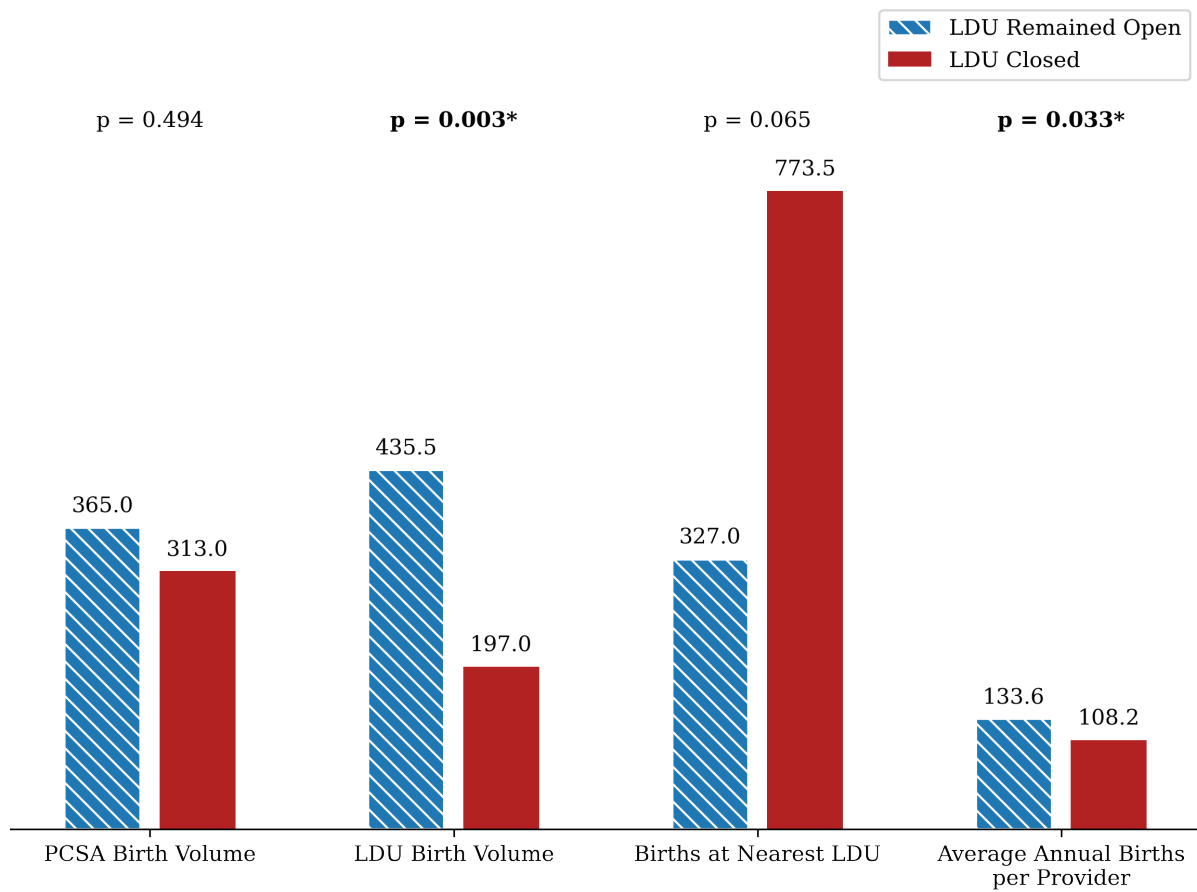


Figure 2: Median birth volumes and provider loads by LDU closure status (2011).

Table S1: PCSAs, Counties, and Closure Status of the Rural LDUs in Sample

LDU	PCSA	Counties	Closed 2012–2016
Fannin Regional Hospital	4	Fannin	No
Union General Hospital	5	Union	No
Stephens County Hospital	8	Stephens	No
Cobb Memorial Hospital	9	Franklin	No
Habersham County Medical Center	10	Habersham, Banks	No
Chestatee Regional Hospital - Sunlink	12	Lumpkin	Yes
Oconee Regional Medical Center	47	Baldwin	No
Washington County Regional Medical Center	48	Washington, Johnson	Yes
Burke Medical Center	50	Burke	Yes
Emanuel Medical Center	57	Emanuel	Yes
Meadows Regional Medical Center	58	Toombs, Montgomery	No
Fairview Park Hospital	60	Laurens, Treutlen	No
Dodge County Hospital	62	Dodge	No
Taylor Regional Hospital	64	Pulaski, Wilcox	No
Crisp Regional Hospital	65	Crisp	No
Phoebe Sumter Medical Center	68	Sumter, Schley	No
Donalsonville Hospital	72	Seminole, Miller	No
Memorial Hospital And Manor	73	Decatur	No
Grady General Hospital	74	Grady	No
John D. Archbold Memorial Hospital	75	Thomas	No
Colquitt Regional Medical Center	78	Colquitt	No
Tift Regional Medical Center	79	Tift, Turner	No
Memorial Hospital Of Adel	80	Cook	Yes
Irwin County Hospital	86	Irwin	No
Dorminy Medical Center	87	Ben Hill	No
Coffee Regional Medical Center	88	Coffee, Atkinson	No
Bacon County Hospital And Health System	90	Bacon	No
Appling Healthcare System	91	Appling	Yes
Wayne Memorial Hospital	92	Wayne, Long	No
Satilla Regional Medical Center	94	Ware, Pierce	No