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PREETHA NANDI Date

Examining changing disparities in teen birth and repeat birth rates in Georgia: implications for teen pregnancy prevention

By

Preetha Nandi
Master of Public Health

Epidemiology

_____

Michael Kramer, PhD, MMSc
Committee Chair

_____

Melissa Kottke, MD, MBA, MPH
Committee Member

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By

Preetha Nandi

B.A., Yale University, 2013

Thesis Committee Chair: Michael Kramer, PhD, MMSc

An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
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Abstract

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Objective: To understand teen birth trends in Georgia by racial and geographic factors.

Study design: We analyzed overall birth and repeat teen birth rates by race, urban/rural status, and adequacy of obstetric care from 2008-2016 using vital records from all Georgia counties. We additionally used Poisson regression using backwards elimination to better characterize independent and interaction effects.

Results: Overall birth rates among teens analyzed decreased dramatically in Georgia, from 45.63 births per 1000 teens in 2008-2010 to 26.28 per 1000 teens in 2014-2016. Repeat birth rates followed a similar decline, from 9.40 to 4.53 repeat births per 1000 teens over the same time period. These rates decreased in all sub-groups of teens, however to varying degrees. The difference in birth and repeat birth rates between black and white teens decreased four-fold during this time period, whereas the declines in these rates for teens living in rural versus urban counties and with inadequate versus adequate obstetric care were less pronounced. The Poisson regressions demonstrated key interaction effects with some exposure variables and a time variable; other effects were not clinically relevant or otherwise relevant for public health interventions.

Conclusion: While remarkable reductions in teen birth and repeat birth rates have occurred since 2008, these declines have not been equally experienced by all groups of teens.

Implications: Our analysis suggests that persistent disparities in teen birth and repeat birth rates exist, particularly in areas with limited or threatened access to reproductive health care. Applying targeted teen pregnancy prevention initiatives to these areas could help ensure equitable health and social outcomes for teens.

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Chapter I: Background and literature review

Overview

Teen pregnancy prevention remains a top public health priority in the United States. Teen births (among 15 to 19 year old females) in the United States have been declining substantially in the past quarter century, from 61.8 to 22.3 live births per 1000 teens between 1991 and 2016 (1). However, teens experience varying declines in birth rates by various demographic factors, including race and geographic characteristics (2, 3, 4). These disparities impact short- and long-term maternal and infant health outcomes and have significant behavioral, social and economic consequences for teen mothers (5). Additionally, females ages 15 to 19 years have the highest rate of unintended pregnancy among all age groups, a notion that warrants public health interventions to prevent teen pregnancy in order to promote teen health and wellness overall (6).

In particular, Georgia has many resources dedicated to maternal and child health and has a similar obstetric workforce to other states, but lags behind in poor maternal and child health outcomes, especially for teens (7). Georgia ranked 19th nationally for highest teen birth rate in 2015, and was 1 of 5 Southeastern states where over 20% of teen births were repeat births between 2007-2010 (8, 9). This thesis aims to: 1) review the literature on progress made in teen pregnancy declines at a national and state level, 2) conduct an ecologic study of teen birth and repeat birth trends in Georgia, 2) identify disparities in these outcomes by racial and geographic factors, and 3) use our analysis to inform current and future public health initiatives in teen pregnancy prevention in Georgia.

National trends in teen pregnancy

The national teen birth rate has been steeply declining since 1991, with an exception of a 5% increase in teen births between 2005 and 2007. In fact, it is estimated that 4 million more births to adolescents would have occurred between 1992 to 2012 if the teen birth rates in 1991 had persisted. However, the United States still has one of the highest teen pregnancy rates in the developed world (10). Additionally, there is variation in the rate of decline between different groups of teens, including differences by race, area of residence, and socioeconomic status.

Between 2007 and 2015, Hispanic teens experienced the largest proportionate decrease in birth rate of 54% but still had the highest birth rate among all racial and ethnic groups. By contrast, non-Hispanic white teens experienced a 41% decline in teen birth rates (1). In 2014, non-Hispanic black and Hispanic teens had twice as many births as non-Hispanic white teens. Ethnic/racial disparities in teen birth rates greatly vary by state (11). While some progress has been made to narrow the difference in declines between birth rates of ethnic minority teens compared to white teens, persistent disparities by race and ethnicity in teen birth and repeat birth rates remain a public health concern.

Compared to differential experiences of teen birth by race and ethnicity, geographic differences in teen birth rates in the United States have not been as well recognized or studied. Between 2007 and 2015, rural counties had persistently higher birth rates compared to their urban counterparts. Additionally, large urban counties experienced a 50% decrease in teen birth rates, whereas rural counties experienced a 37% decrease (4). More broadly, a multitude of studies on the impact of socioeconomic (SES)

factors on teen pregnancy suggest that many contextual factors, such as educational attainment, employment, neighborhood, low income, and inequality, impact rates of teen pregnancy in community after adjusting for race and ethnicity (12).

In summary, extensive research suggests that various social determinants of health mediate and independently contribute to teen birth trends in the United States, and progress in lowering teen birth rates has been experienced differentially by different populations of teens.

Facilitators of progress in declining teen births

Declines in teen pregnancy can be generally attributed to two factors: changes in adolescent sexual behaviors and use of contraception (13). While delayed sexual activity certainly influences teen birth rates, increased contraception uptake among teens is likely predominantly responsible for decreasing teen pregnancy rates since 1995, particularly for teens ages 15 to 17 years (14, 15). We will briefly discuss the driving forces of these two factors in the context of declines in teen birth.

There is conflicting reported evidence on whether teens are delaying initiation of sexual intercourse. Data from the National Survey of Family Growth (NSFG) suggest that overall sexual activity rates among teen females and males in 2011-2015 were similar to the rates surveyed in 2002 and in 2006-2010 (16). However, analysis of the Youth Risk Behavior Surveys (YRBS) from 29 states suggests a linear decrease in the prevalence of ever having sexual intercourse among teens. This decrease was more prominent among racial and ethnic minority teens compared to white teens, as well as among 9^{th} and 10^{th} graders compared to 11^{th} and 12^{th} graders (17). Delayed sexual

activity among teens could be due to many reasons, such as access to information and education about sexual activity, parental involvement and monitoring, and community support (18). Irreverent of the epidemiologic trend of declining or stable rates of teen sexual activity, a significant portion of teens (i.e. over half of high-school students) self-report graduating high school "being sexually active," increasing risk for not just unwanted pregnancy but also sexually transmitted diseases (17). Therefore, addressing teen sex activity and preferences in the context of tackling teen pregnancy prevention has productive spillover effects for other public health issues.

Increased uptake of contraceptive methods by teens is arguably the main driver of recent trends in teen pregnancy, particularly among 18 to 19 year olds who account for 69% of teen pregnancies (13). The contributors to this trend are likely multifactorial, and involve social and contextual factors at an individual, family and community level. Increased education targeted to teens about risky behaviors in general likely impact contraceptive uptake and safe sex practices, and these behavior changes translate to fewer teen births (19). Increased awareness of the benefits of contraception, both from the changing medical practice to recommend long-term reversible contraception (LARC) and media attention, also likely contribute to this trend (13, 20). Other contextual factors such as changing cultural norms around initiating sex or family values around discussing protected sexual behavior may also have an influence (21). Examining the complexity and differing contributions of all of these factors is a dynamic and ongoing research endeavor by the public health community.

Health, social and economic impact of teen pregnancy

Extensive research shows that teen mothers face health and social consequences for both themselves and their infants. These adverse outcomes from teen birth are especially troubling from a reproductive justice standpoint given that teens experience the highest rate of unwanted pregnancy among all age groups (6, 22). Teen mothers are at increased risk for poor perinatal outcomes – infants to teen mothers are more likely to be preterm, have low birth weight, be small for gestational age, have malformations and have a higher infant mortality in first year of life (23, 24). Adolescents who give birth also have increased rates of postpartum depression. Furthermore, these teens have increased risk for poor long-term physical and mental health outcomes, likely due to a combination of economic sequelae of teen pregnancy and increased stress of childrearing at a young age that do not allow for investment in personal health (25).

Teen mothers also have lower educational attainment, significantly more time spent as a single mother, and worse socioeconomic opportunities compared to their counterparts that delay motherhood (26, 27). These mothers are also at risk for failing school, substance abuse and intimate partner violence (24). This social context feeds an intergenerational impact of teen pregnancy – having a mother who gave birth as a teen is an independent risk factor for teen pregnancy itself, even after adjusting for socioeconomic factors (12, 28). These barriers to socioeconomic growth perpetuate a cycle of poverty and inequality for teens.

Teen pregnancy accounts for high healthcare and social costs in the United States. Three-quarters of all teen mothers are enrolled and receive public assistance within the first 3 years of their child's birth. Teen pregnancy costs taxpayers billions of dollars

annually, primarily through increased costs for healthcare, welfare, state prison systems, and lost revenue from the mothers and their children (29).

Overview and implications of repeat teen pregnancy

Teen repeat births, (i.e. teen births that were not first live births) are an undervalued public health indicator for tracking trends in teen pregnancy – this vital measurement represents a failure of prevention among a vulnerable populations (i.e., recently delivered teen mothers) who could have benefited from education, community support and access health services in their first pregnancy.

Teen repeat birth rates have followed national trends in teen birth rates and have been declining overall. Specifically, teen repeat births have decreased 53.8% from 2004 to 2015. However, many teens still experience repeat births. In 2015, 16.7% of all teen births were repeat births, and this proportion was higher for ethnic minorities (18.7% and 17.9% for Hispanic and non-Hispanic black teens, respectively) (9, 30). There is considerable state-by-state variation in repeat birth rates among adolescents. In 2010, Texas had the highest percentage of repeat births among teen births (22%); the lowest percentage was in New Hampshire (10%). Additionally, 5 Southeastern states had proportions of repeat births greater than 20% (9).

Low rates of postpartum contraception use and use of least effective contraception methods contribute to continued repeat pregnancy among adolescents. Between 2004 and 2013, 82.7 – 90.8% of teens used a contraceptive method postpartum. The proportion of teens that use postpartum contraception who were using most effective reversible methods, such as an intrauterine device or implant, increased from 5.3% to 25.3%. In

contrast, the proportion of teens that used least effective methods, including condoms, diaphragms, and withdrawal, as well as the proportion of teens that used no method did not change significantly over this time period (30).

Repeat childbearing for teens produces both health and social risks to the livelihoods of a teen mother and her child. Rapid repeat pregnancy increases many health risks for the mother and infant, including preterm birth, low birth weight, and infant mortality (9, 31, 32). Teen mothers who experience repeat births have an exacerbated burden of education and job development that already accompanies being a teen parent (33).

Few interventions have been studied or implemented in a targeted way to reduce rapid repeat pregnancy in teens. Motivational interviewing based interventions as well as frequent home visits have shown some success but more research on targeted prevention approaches is warranted (34).

Regional characteristics of teen birth in Georgia

By various metrics, Georgia has historically experienced poor reproductive health outcomes. Georgia has had high rates of teen births and repeat births compared to national averages (8, 9). Georgia also has the highest maternal mortality rate in the United States, and the 11th highest infant mortality rate, as well as persistent racial and socioeconomic disparities in these health outcomes (7, 35, 36).

A hypothesis for this reproductive health landscape of the state is the maldistribution of health care providers, particularly obstetricians, and scarcity of these providers in rural areas. Seventy-nine of 159 counties in Georgia do not have a practicing

obstetrician-gynecologist (ob/gyn), and there was a 40% decline in labor and delivery units between 1995 and 2015 (37). This reduced access to obstetric services likely reflects the larger scarcity in accessing reproductive health services in general, and this health climate likely affects teen health outcomes, from preventative services to prenatal care and follow-up counseling.

Chapter II: Methods and results

Published manuscript: Nandi, P., Kramer, M., & Kottke, M. (2018). Changing disparities in teen birth rates and repeat birth rates in Georgia: implications for teen pregnancy prevention. *Contraception*.

The following work was published in 2018 as an *Original Article* in the *Contraception* journal, an international peer-reviewed journal on reproductive health topics.

Abstract

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Conclusion: While remarkable reductions in teen birth and repeat birth rates have occurred since 2008, these declines have not been equally experienced by all groups of teens.

Implications

Our analysis suggests that persistent disparities in teen birth and repeat birth rates exist, particularly in areas with limited or threatened access to reproductive health care. Applying targeted teen pregnancy prevention initiatives to these areas could help ensure equitable health and social outcomes for teens.

Keywords

Teen pregnancy, teen births, repeat births, racial disparity, urban/rural, obstetric shortage

1. Introduction

Nationally, teen birth rates have declined substantially, from 61.8 to 22.3 live births per 1000 teens between 1991 and 2016 (1). While teen birth rates have declined for all groups of teens, significant disparities in teen birth rates by race and urban/rural residence have persisted and widely vary by region (2, 3, 4). Teen birth remains a pertinent public health issue as it is associated with poor social and health consequences for teen mothers and their infants, as well as high taxpayer costs. Teen mothers have lower educational attainment, fewer socioeconomic opportunities, and worse health outcomes compared to their counterparts who delay motherhood (25, 38). Additionally, repeat teen birth, which accounted for one-sixth of all teen births in 2015, exacerbates

these barriers in achieving social and health well-being that already accompany teen parenting (30).

Georgia has made some compelling strides in reproductive health, but still experiences many health outcomes that are below national averages. Georgia ranked 19th nationally for highest teen birth rate in 2015, and was 1 of 5 Southeastern states where over 20% of teen births were repeat births between 2007-2010 (8, 9). Notably, Georgia is experiencing a dearth of obstetric care in rural areas (37). This ecologic study aimed to examine changes in birth and repeat birth rates among different groups of teens in Georgia.

2. Methods

2.1. Data source and calculations

We used data from the publicly available Online Analytical Statistical Information System (OASIS) published by the Georgia Department of Public Health (https://oasis.state.ga.us/) (39). We abstracted yearly birth, repeat birth, and population counts by county for females ages 15 to 19 years that identified as white or black/African-American. We collated these counts over three time periods: 2008-2010, 2011-2013, 2014-2016. Birth rates were calculated as number of live births divided by the female population per county. Repeat birth rates were calculated similarly with a numerator of number of live births that were not first live births.

2.2. Exposure classification

Predictor variables included individual race (black/African-American or white) and county-level urban/rural status and adequacy of obstetric care; births that were not

classified within these race parameters were excluded from this analysis. Stratification by Hispanic ethnicity was not possible due to missing data. 2000 U.S. Census data defined rural counties as those with fewer than 35,000 total population and urban counties otherwise. We specified adequacy of obstetric care by county based on levels of care delivered in 2011, as collected by the Georgia Maternal and Infant Health Research Group (GMIHRG) (37). Following this work, we classified inadequate obstetric care as counties with no obstetric services or those with average annual births per provider greater than 166, and adequate obstetric care otherwise.

2.3. Statistical analysis

We tested unadjusted differences in birth and repeat birth rates by each predictor using two-sample t-tests. We also conducted a three-way analysis of variances (ANOVA) to test independent and interaction associations of our three predictor variables on birth and repeat birth rates. Statistical analyses were performed using Statistical Analytic Software (SAS) 9.4 (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. Descriptive characteristics of data

Of 159 counties in Georgia, 108 (68%) were rural and 51 (32%) were urban. Additionally, 57 counties (36%) had inadequate obstetric care and 102 counties (64%) had adequate obstetric care.

3.2. Trends in birth and repeat birth rates by individual predictor variables

Among the teens analyzed, Georgia-wide teen birth and repeat birth rates decreased. The birth rate in 2008-2010 was 45.63 births per 1000 teens, which declined

to 34.00 births per 1000 teens in 2011-2013 and 26.28 births per 1000 teens in 2014-2016. Repeat birth rates reflected a similar trend, with 9.40 repeat births per 1000 teens in 2008-2010, 6.52 repeat births per 1000 teens in 2011-2013, and 4.53 repeat births per 1000 teens in 2014-2016.

Teen birth rates and repeat birth rates in Georgia also decreased for all sub-groups analyzed; however, the magnitude of decline differed by each predictor (Figure 1). Between 2008 and 2016, the differences in birth and repeat birth rates between black and white teens decreased approximately four-fold each, from 20.25 ($p<0.001$) to 4.87 ($p=0.01$) births per 1000 teens and 5.43 ($p<0.001$) to 1.15 ($p=0.04$) repeat births per 1000 teens. The declines in teen birth and repeat birth rates over time between rural and urban counties were less pronounced compared to those observed for race, with rural counties experiencing consistently higher rates. The difference in births per 1000 teens between rural and urban counties was 11.26 ($p<0.001$) in 2008-2010 and 9.14 ($p<0.001$) in 2014-2016; the rural/urban difference in repeat birth rates during this time were 2.33 ($p=0.02$) and 1.47 ($p=0.02$) repeat births per 1000 teens, respectively.

Our third predictor, adequacy of obstetric care, was used as a proxy for access to reproductive health care. Notably, 44.4% of rural counties were classified as having inadequate obstetric care, compared to 17.6% of urban counties. Consequently, the disparities in birth and repeat birth rates between counties with inadequate versus adequate care were similar to those of rural versus urban counties. Compared to counties with adequate care, counties with inadequate care experienced a higher birth rate by 11.69 births per 1000 teens ($p<0.001$) and a higher repeat birth rate by 3.44 repeat births per 1000 teens ($p=0.001$) in 2008-2010; these differences continued in 2014-2016, with a

birth rate difference of 8.38 births per 1000 teens ($p<0.001$) and repeat birth rate difference of 1.35 repeat births per 1000 teens ($p=0.03$).

3.3. ANOVA results

Birth and repeat birth rates were calculated by race and stratified by urban/rural status and adequacy of obstetric care (Table 1). Black rural teens with inadequate obstetric care had the highest birth rates across all time periods, and white urban teens with adequate obstetric care had the lowest; repeat birth rates demonstrated more variation. When using three-way ANOVA to assess independent and interaction associations, race was the only variable with significant association between 2008-2010 ($p<0.001$). However, all three predictors, i.e. race, urban/rural status, and adequacy of obstetric care, had statistically significant associations with birth rate between 2011-2013 (race: $p<0.001$; urban/rural status: $p=0.01$; adequacy of obstetric care: $p=0.001$) and 2014-2016 (race: $p=0.02$; urban/rural status: $p=0.01$; adequacy of obstetric care: $p<0.001$). When comparing repeat birth rates, race and adequacy of obstetric care were significantly associated with repeat birth rates between 2008-2010 (race: $p<0.001$; adequacy of obstetric care: $p=0.04$) and 2011-2013 (race: $p<0.001$; adequacy of obstetric care: $p=0.02$); only adequacy of obstetric care was significantly associated with repeat birth rates between 2014-2016 ($p=0.03$). For all of these analyses, no statistical interaction was observed.

4. Discussion

Teen birth and repeat birth rates have decreased among all teens in Georgia, similar to observed national trends (1). However, the extent of decline in these rates

varied by race and geographic factors. Our data suggest that racial disparity in teen birth and repeat birth rates in Georgia has narrowed over the past decade. Conversely, the gaps in these rates for rural versus urban areas and for areas with inadequate versus adequate obstetric care have persisted during this time period. Examining stratified birth and repeat birth rates by all three predictors reveals potentially shifting trends, and no interaction associations were found between these factors.

Our analysis was strengthened by our reliance on population-based vital records. However, our study used dichotomous definitions for covariates, which may have masked finer variation. We also used definitions for urban/rural status and adequacy of obstetric care that were determined in 2000 and 2011, respectively, and these values for a county may have changed during our time period of interest. However, when analyses were repeated using a more conservative coding schema, the observed trends remained statistically significant. Additionally, data for other variables that could have confounded our results were not available through OASIS. Prior research suggests that racial and regional disparities in birth rates may be related to structural variables, such as educational attainment (40). Further research beyond this descriptive analysis is warranted to assess for potential confounding.

Declining teen pregnancy rates are likely due to improved contraception use and changing sexual behaviors (13). Our descriptive findings suggest this progress is unevenly shared. Reducing disparities in teen pregnancy is pivotal to achieving equitable health outcomes and social opportunities for all teens. Our analysis implies a need to apply teen pregnancy prevention strategies that have been effective for reducing the racial disparity in Georgia teen birth and repeat birth rates towards rural areas of the state and

those with barriers in accessing reproductive health services. Additionally, our analysis suggests that tracking changes in provision of reproductive health services may be useful in assessing reproductive health outcomes. With a growing health care need in rural areas, policymakers and community stakeholders should focus on these areas in order to reduce teen birth.

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Conflicts of interest

Declarations of interest: none.

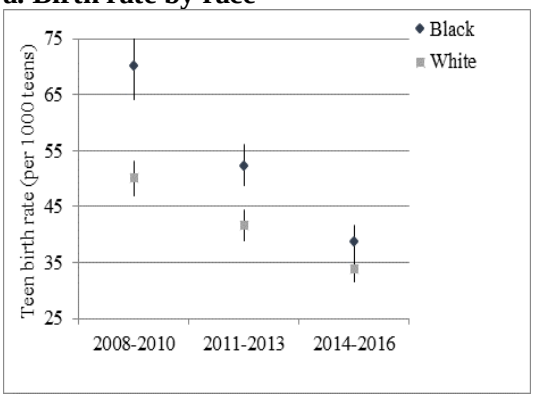
Table 1: Teen birth rates (BR) and repeat birth rates (RBR) among Georgia counties (N=159) by race, stratified by urban/rural status and adequacy of obstetric care[a]

	Teen birth rate[b]			**Teen repeat birth rate[b]**		
	2008-2010	2011-2013	2014-2016	2008-2010	2011-2013	2014-2016
Rural, inadequate OB (N = 48)						
Black	74.35	60.47	46.83	16.71	12.42	8.07
White	55.53	47.86	38.92	12.21	9.06	6.12
Rural, adequate OB (N = 60)						
Black	70.34	52.48	38.58	14.51	10.03	6.46
White	51.73	42.75	34.35	9.18	7.40	5.94
Urban, inadequate OB (N = 9)						
Black	76.46	57.97	43.74	17.85	12.40	7.50
White	52.00	42.26	36.22	10.41	7.54	6.75
Urban, adequate OB (N = 42)						
Black	64.42	42.03	28.99	14.02	8.95	5.62
White	40.90	32.81	27.11	7.76	5.56	4.42

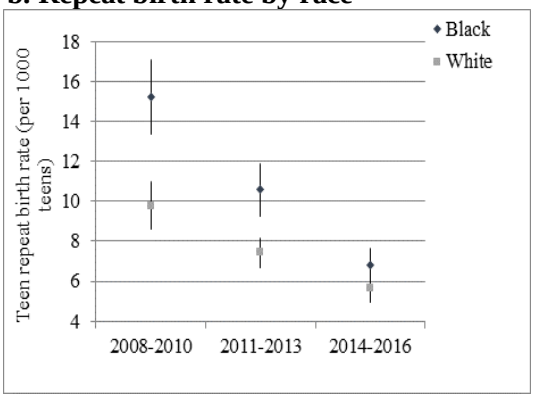
[a] Calculated rates from data provided the Online Analytical Statistical Information System published by the Georgia Department of Public Health (https://oasis.state.ga.us/). Race was reported to OASIS from vital records; urban/rural status was obtained from 2000 U.S. Census parameters; obstetric care was classified as adequate ("adequate OB") or inadequate ("inadequate OB") based on levels of care delivered in 2011 collected by GMIHRG.
[b] Birth rate and repeat birth rates are reported per 1000 females ages 15 to 19 years.

Figure 1: Comparison of teen birth rates and repeat birth rates among Georgia counties by race, urban/rural status, and adequacy of obstetric care, 2008-2016[a]

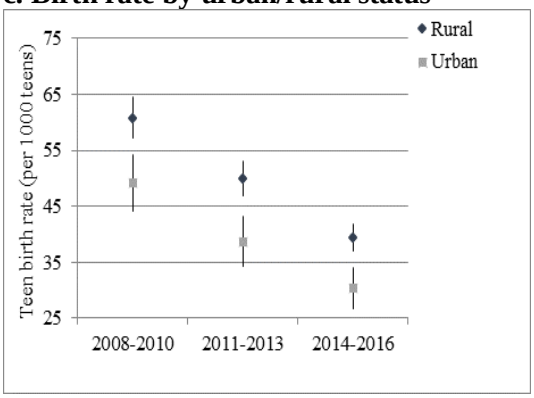
a. Birth rate by race



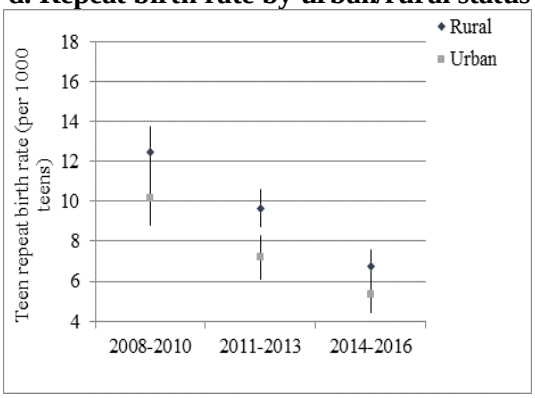
b. Repeat birth rate by race



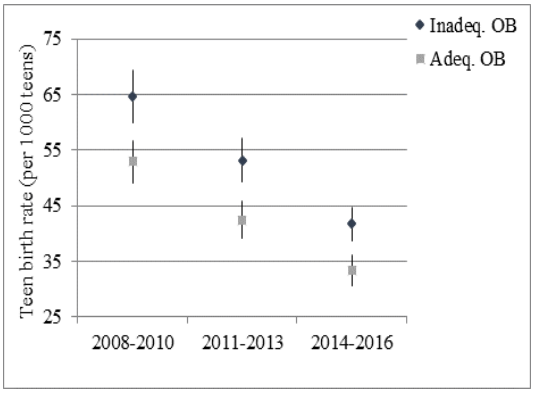
c. Birth rate by urban/rural status[b]



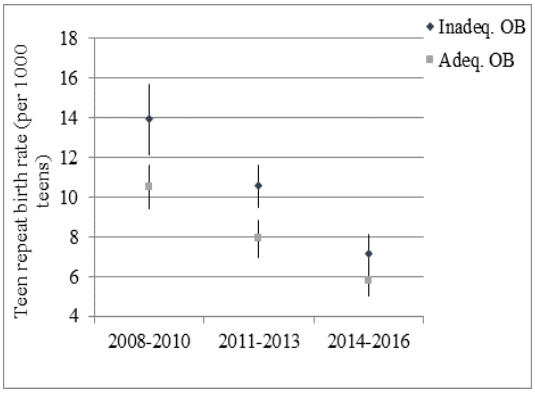
d. Repeat birth rate by urban/rural status



e. Birth rate by adequacy of obstetric care[c]



f. Repeat birth rate by adequacy of obstetric care



[a] Calculated rates from data provided the Online Analytical Statistical Information System published by the Georgia Department of Public Health (https://oasis.state.ga.us/).
[b] Rural counties were defined as those with less than 35,000 total population by 2000 U.S. Census data, and counties were defined as urban otherwise.
[c] Counties with inadequate obstetric care ("Inadeq. OB") were defined as those with no obstetric services or those with average annual births per provider greater than 166, and counties were defined as having adequate obstetric care ("Adeq. OB") otherwise.

Additional methods: Poisson regression models

We were interested to model this data using a Poisson regression in order to better assess the independent and interaction effects of race, urban/rural status and level of obstetric care in the context of a changing time variable. We conducted a backwards elimination analysis for both birth rates and repeat birth rates on two "full" models each that included both main and interaction effects of the following variables:

Model 1: race, urban/rural status, and year, and the corresponding interaction variables, i.e.

Log (**births**) = $\alpha_1 + \beta_1$ (black) + β_2 (rural) + β_3 (year) + β_{12} (black*rural) + β_{13} (black*year) + β_{23} (rural*year) + ln(number of females ages 15-19 years old)

Model 2: race, urban/rural status, obstetric provision, and year, and the corresponding interaction variables, i.e.

Log (**births**) = $\alpha_1 + \beta_1$ (black) + β_2 (rural) + β_3 (inadequate) + β_4 (year) + β_{12} (black*rural) + β_{13} (black*inadequate) + β_{14} (black*year) + β_{23} (rural*inadequate) + β_{24} (rural*year) + β_{34} (inadequate*year) + β_{123} (black*rural*inadequate) + β_{124} (black*rural*year)+ β_{134} (black*inadequate*year) + β_{234} (rural*inadequate*year) + β_{1234} (black*rural*inadequate*year) + ln(number of females ages 15-19 years old)

Model 3: race, urban/rural status, and year, and the corresponding interaction variables, i.e.

Log (**repeat births**) = $\alpha_1 + \gamma_1$ (black) + γ_2 (rural) + γ_3 (year) + γ_{12} (black*rural) + γ_{13} (black*year) + γ_{23} (rural*year) + ln(number of females ages 15-19 years old)

Model 4: race, urban/rural status, obstetric provision, and year, and the corresponding interaction variables, i.e.

Log (repeat births) = $\alpha_1 + \gamma_1$ (black) + γ_2 (rural) + γ_3 (inadequate) + γ_4 (year) + γ_{12} (black*rural) + γ_{13} (black*inadequate) + γ_{14} (black*year) + γ_{23} (rural*inadequate) + γ_{24} (rural*year) + γ_{34} (inadequate*year) + γ_{123} (black*rural*inadequate) + γ_{124} (black*rural*year)+ γ_{134} (black*inadequate*year) + γ_{234} (rural*inadequate*year) + γ_{1234} (black*rural*inadequate*year) + ln(number of females ages 15-19 years old)

During this analysis, we used a generalized estimating equation by including a "repeated" statement in our code to account for possible covariance between outcomes. We also included a parameter to account for multiple predictor variables, i.e. race and year, to be nested within a specific county. Statistical analyses were performed using Statistical Analytic Software (SAS) 9.4 (SAS Institute Inc., Cary, NC, USA). Predictors were considered statistically significant if they yielded a p value of less than 0.05.

Additional results: Poisson regression models

We ran Model 1 in order to use predictor variables, i.e. race and urban/rural status, that have been commonly used in previous literature and have been defined by the OASIS system. Model 2 adds our constructed variable of level of obstetric care, which can elucidate additional effects to consider when modeling birth and repeat birth outcomes.

The best models (described as Model 1' and Model 2') after successive elimination of insignificant terms from the respective full models are described in Table 2a and Table 2b below.

Table 2a: Poisson regression analysis for birth rates per 1000 teens (regression coefficient estimates)

Variable[#]	**Model 1 (SE)**	**Model 1' (SE)** ^	**Model 2 (SE)**	**Model 2' (SE)** ^
BLACK	**0.461**** (0.083)	**0.425**** (0.068)	**0.469**** (0.090)	**0.430**** (0.067)
RURAL	0.230 (0.118)	--	0.112 (0.141)	--
INADEQ			0.260 (0.165)	**0.327**** (0.112)
YEAR	**-0.077**** (0.005)	**-0.076**** (0.004)	**-0.077**** (0.005)	**-0.078**** (0.005)
BLACK*RURAL	-0.150 (0.100)	--	-0.173 (0.124)	--
BLACK*INADEQ			-0.037 (0.102)	--
BLACK*YEAR	-0.022 (0.004)	**-0.021**** (0.004)	**-0.022**** (0.004)	**-0.020**** (0.004)
RURAL*INADEQ			0.129 (0.205)	--
RURAL*YEAR	0.005 (0.008)	--	-0.001 (0.010)	--
INADEQ*YEAR			0.008 (0.008)	**0.016**** (0.006)
BLACK*RURAL*INADEQ			0.031 (0.146)	--
BLACK*RURAL*YEAR	0.001 (0.008)	--	0.001 (0.011)	--
BLACK*INADEQ*YEAR			0.012 (0.223)	--
RURAL*INADEQ*YEAR			0.008 (0.013)	--
BLACK*RURAL*INADEQ*YEAR			-0.007 (0.016)	--

#The variables below are all binary categorical variables as follows: "BLACK" indicates race where the value 1 represents black or African-American race, and 0 represents white race; "RURAL" indicates urban/rural status of a county where the value 1 represents a rural county, and 0 represents an urban county; "INADEQ" indicates level of obstetric care where the value 1 represents inadequate care, and 0 represents adequate care. The variable "YEAR" is a numeric variable which is centered at 2008 and proceeds in 1-year increments to 2016.

*$p \leq 0.05$, **$p \leq 0.01$

^These variables were removed from the full model using a backwards elimination approach.

Table 2b: Poisson regression analysis for repeat birth rates per 1000 teens (regression coefficient estimates)

Variable[#]	**Model 3 (SE)**	**Model 3' (SE)** [^]	**Model 4 (SE)**	**Model 4' (SE)** [^]
BLACK	**0.560**** (0.104)	**0.569**** (0.083)	**0.573**** (0.114)	**0.568**** (0.082)
RURAL	**0.250*** (0.125)	**0.285*** (0.126)	0.075 (0.142)	--
INADEQ			0.253 (0.200)	**0.419**** (0.134)
YEAR	**-0.109**** (0.007)	**-0.101**** (0.006)	**-0.110**** (0.008)	**-0.101**** (0.006)
BLACK*RURAL	0.031 (0.138)	--	0.028 (0.155)	--
BLACK*INADEQ			-0.096 (0.165)	--
BLACK*YEAR	-0.018 (0.009)	**-0.025**** (0.009)	-0.019 (0.010)	**-0.025**** (0.008)
RURAL*INADEQ			0.261 (0.248)	--
RURAL*YEAR	**0.028*** (0.012)	--	**0.031*** (0.014)	--
INADEQ*YEAR			0.015 (0.018)	--
BLACK*RURAL*INADEQ			0.012 (0.232)	--
BLACK*RURAL*YEAR	-0.029 (0.018)	--	-0.028 (0.024)	--
BLACK*INADEQ*YEAR			0.019 (0.028)	--
RURAL*INADEQ*YEAR			-0.019 (0.026)	--
BLACK*RURAL*INADEQ*YEAR			-0.014 (0.041)	--

#The variables below are all binary categorical variables as follows: "BLACK" indicates race where the value 1 represents black or African-American race, and 0 represents white race; "RURAL" indicates urban/rural status of a county where the value 1 represents a rural county, and 0 represents an urban county; "INADEQ" indicates level of obstetric care where the value 1 represents inadequate care, and 0 represents adequate care. The variable "YEAR" is a numeric variable which is centered at 2008 and proceeds in 1-year increments to 2016.

*$p \leq 0.05$, **$p \leq 0.01$

[^]These variables were removed from the full model using a backwards elimination approach.

The best fit models for births (i.e. Models 1' and 2') suggest that the main effects of race and year, and the interaction effect of (race) x (year) significantly model teen birth counts; when adding the potential effects of level of obstetric care, the main effect of this variable as well as the interaction effect of (level of obstetric care) x (year) are also significant. The coefficients of the interaction variables show that while teen births were decreasing each year, black teens and teens living in rural areas had an additional decline in their births based on these qualifying factors. Additionally, the relative similar magnitudes of the coefficients for race and level of obstetric care, and the lack of a significant interaction between these variables, implies that our characterized variable was important to include in this model.

The best fit models for repeat births (i.e. Models 3' and 4') the main effects of race, and year, and the interaction effect of (race) x (year) significantly model teen birth counts. Interestingly, Model 3' also included the predictor of urban/rural status, and Model 4' included the predictor of level of obstetric care. As discussed previously, the classification of these variables may share features relevant to public health. In other words, rural communities and areas of inadequate access to care likely have some shared trends in health outcomes, and in this case, repeat births. We observe a similar interaction effect as our best fit model for birth between race and year.

Chapter III: Public health implications and future research

Our results illustrate progress in reducing teen birth and repeat birth rates in Georgia across all groups of teens, but also highlight many opportunities for public health interventions to improve disparities in teen health outcomes. Due to the many health and social consequences of teen pregnancy described in this work, efforts to prevent teen pregnancy ought to address inequity in these outcomes, particularly for disparities that have persisted despite improvements in teen pregnancy. Additionally, effective policy that focuses on risk reduction for teen pregnancy has many spillover effects on other health issues that impact teens, including sexually transmitted disease, alcohol and drug use, and general health maintenance and prevention (41). Many effective public health strategies and policy changes have yielded reductions in teen births, and we will discuss the evidence behind a few core strategies below.

Targeted strategies for teen pregnancy prevention

Contraception access

Uptake and access to effective contraception has played a pivotal role in shaping progress in teen pregnancy prevention. Further, the American College of Obstetricians and Gynecologists and the American Academy of Pediatrics strongly support access to all forms of contraception to adolescents before and after pregnancy, including long-acting reversible methods (LARC) such as intrauterine devices (IUDs) or implants (42).

However, many factors contribute to a teen's inability to obtain desired contraceptive methods, including cost, education and availability of methods (43). The CHOICE project illuminated the unmet need of teens for contraceptive use with a reliable study design that addressed these three issues. The project was a prospective cohort study with over 10,000 participants in a large urban area that utilized tiered effectiveness counseling for contraception and offered all contraceptive methods to study participants for no fee. The research team found that not only is LARC widely accepted by sexually active women who desire to prevent pregnancy, but also that this choice did not clinically vary by demographic variables such as race, parity, marital status, or history of abortion (44). Specifically looking at the 1404 teens who participated in the CHOICE project, 72% of teen participants chose a LARC method, and observed rates of pregnancy, birth and abortion were much lower than national average data (44). Another prospective cohort study showed that pregnant teens who used a contraceptive implant as postpartum contraception had significantly lower rates of repeat pregnancy compared to those using oral contraceptive pills or depo-medroxyprogesterone acetate (DMPA) injections (45). These findings suggest that teens benefit and choose effective contraceptive methods when barriers to education and cost are removed, and perhaps even more paramount is that teens of all backgrounds desire contraceptive access.

It is important to recognize barriers to accessing contraception that are unique to the adolescent experience. Teens, particularly those living in rural or small communities, combat issues of anonymity when seeking reproductive health services and associated stigma for sexual activity. When quantifying these barriers to accessing contraception, a research group identified that although rural teens report higher barriers to contraceptive

access, the rates of contraceptive use were similar between urban and rural teens (46). Adolescents also may seek no-cost contraception using Medicaid or Title X programs without parental notification, however patients on private insurance of their parents may or may not be eligible for free contraception without parental notification (43). Confidentiality with a health care provider also plays a role in a teen's ability to ask for and obtain desired contraception (47). In a survey of almost 1200 ob/gyns, 94% of providers indicated that they would provide contractive options without parental notification, but 47% of respondents would encourage parental involvement in the decision (48). In practical terms, data from the National Survey on Family Growth revealed that only 38% of teens aged 15 to 17 years old were seen during a visit with a health care provider without a parent, guardian or relative present (47). Teens may perceive this counseling in different ways and may harness fear of a breach of confidentiality when seeking these services. This aspect of health care delivery for adolescents should be considered with attempts to improve teen experience in accessing contraception.

Many innovative solutions have been implemented and effective in increasing access to contraception for teens. Specifically, expanding contraceptive service delivery in areas beyond the ob/gyn office has been shown effective. Offering availability of contraceptive methods through primary care settings and school-based settings is a promising venue for increased access to reproductive health services in general (49). Additionally, providing universal no-cost contraception is an important provision for teens that experience cost and confidentiality as barriers to using contraception (43).

Sexual health education

It is difficult to assess the effect magnitude of increasing knowledge among adolescents of the health risks of sexual behavior, including pregnancy, on reducing teen pregnancy or sex initiation. However, clear evidence from a myriad of studies demonstrates that comprehensive sex education programming promotes safer sexual practices and impacts health exposure risk among teens. Not only do these programs improve sexual literacy and delay sex initiation, but also they decrease the number of partners of teens and increase the likelihood of using contraception, including condoms (13, 50). Conversely, increasing focus on abstinence in sex education curricula by states, including abstinence-only curricula, demonstrates a positive correlation with high teen pregnancy and birth rates (51).

However, the causal quandary of sexual health education and teen pregnancy has many potential contextual factors that influence this relationship. The diversity of sexual health curricula across the Unites States and what curricula qualify as comprehensive sexual education is a moving target. While many studies report differing effects of sexual health education on pregnancy based on a range of curriculum topics and methodologies, most have a consensus that abstinence-only education programs are ineffective at reducing teen pregnancy and births, and curricula that includes abstinence as well as information on contraception use, infection risk, and safe practices are the most effective at improving teen health (19). Additionally, there are many potential confounders to this relationship. A large prospective cohort study showed that implementing sex education curricula in schools was associated with lower teen birth rates; however, after adjusting for measures pertaining to religiosity and conservatism, the effect of the intervention was

equivocal. That is, teen birth rates did not decline in this setting in spite of enacting sexual health education, presumably as a result of these contextual mediators (52).

Implementation of effective sex education a challenging task in the United States. Federal funding sources for both abstinence-only and comprehensive sex education have influenced state policy on programming choices. The most notable federal pushes for abstinence-only education include the Adolescent Family Life Act (AFLA), Community-Based Abstinence Education (CBAE) and Title V; the most significant federal contribution for comprehensive sex education was an initiative under the Obama administrative to teach medically accurate, age appropriate topics (13). The attitudes around changing sex education curricula remain varied by region and politically charged.

Social support for teens

The sociobehavioral factors that contribute to reducing teen pregnancy expand beyond the realm of reproductive health. There is more and more evidence that community-based initiatives work well to address many interwoven factors in teen health and wellness (24). Programs in early education that teach the importance of family connectedness as well as social skills, or those that focus on job development and education, prevent teen pregnancy (50). Interventions on individual, school, clinic and community levels contribute not only short term effects on decreasing teen pregnancy, such as increasing access to contraception or information about safe sex practices, but also add value to long term cultural shifts, such as normalizing later childbearing and helping foster maternal and child connections to improve familial health outcomes overall (13, 15, 53). Many structural factors, including planned public health programs or

general changes in economic or social context, must have an active role in effective teen pregnancy prevention strategies.

Threats to progress in teen pregnancy prevention in Georgia

Publicly funded health centers, which receive support from Medicaid, Title X, and other federal sources, are a cornerstone to the provision of reproductive health service delivery in Georgia. These centers provided contraception to 25,140 teens in 2014 (54). Georgia has also benefitted from receiving Teen Pregnancy Prevention (TPP) funding from the Office of Adolescent Health (OAH), primarily used for instituting evidence-based sexual health education programming across the state. However, the longevity of this program, and the $6 million it provides to the state, was threatened by the Trump administration when it terminated all of the OAH TPP grants. These programs were reinstated federally in 2018 through a series of legal actions (55). Additionally, Georgia continues to provide significant state funding to crisis pregnancy centers. Many of these facilities not only provide scientifically inaccurate and potentially harmful information to pregnant teens, but also are charged with teaching abstinence-based sex education curricula in public schools (56). These actions to restrict evidence-based manners for addressing teen reproductive health issues occur within the context of overall poor reproductive health outcomes and a diminishing physician workforce across the state (37). In order to expect meaningful and lasting improvements in teen pregnancy in Georgia, particularly for vulnerable groups of teens, recommendations of evidence-based public health strategies, such as promoting comprehensive sexual health education and

improving contraception and reproductive health care access among teens, will need to be trusted and supported by the state's legislators and political leaders.

Future research directions

Examining trends in teen pregnancy, and further building effective public health interventions in prevention, warrants careful consideration of many interwoven and complicated relationships between contributory factors. This descriptive study highlights important changes in disparities between different groups of teens; however, these declines in births and repeat births evolve in the vibrant context of these teens' lives. Contraceptive access and use, sexual activity, exposure to sex education, and socioeconomic and community circumstances undoubtedly play critical roles in rates of births and repeat births, and based on previous literature and current theories, we speculate these as mediators of these trends. But further research to better define the specific effects of these factors discussed is required. We also were intrigued by a relative paucity of epidemiology of repeat teen pregnancy in the literature, and see further research in this area as a great opportunity for prevention efforts. Lastly, uncovering the true motivation behind these behaviors, ideally in a systematic and well-designed approach, would greatly inform how to develop and sustain efforts in teen pregnancy prevention.

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